[redacted]

[redacted]

From: McKernan, Patrick (NE) [redacted]
Sent: 23 June 2016 11:16
To: Simon Davis
Subject: RE: Further information for application no. P/97/15/PL - Pagham Harbour managed breach

Dear Simon

Further to the email yesterday to Arun DC providing NE's response to the Pagham further information consultation, I thought it would be helpful if I sent through the complete package of NE's advice referred to in our response letter so that you have all of the information together for your records. The package of advice comprises the following items which are attached:

A. Natural England's draft conservation advice package for Pagham Harbour Marine Conservation Zone (MCZ).

B. Natural England's draft conservation advice package for Pagham Harbour Special Protection Area (SPA).

(Please note that both conservation advice packages are draft for consultation purposes, and the SPA version is an early draft we have shared prior to its draft publication to help with this proposal, and is subject to change).

C. Professor Orford's Report - Geomorphological Advice in respect of the proposal for the breaching of Pagham Spit.

D. Specific comments from Natural England on the impacts and potential mitigation measures for the proposal – two documents, one for the SPA and one for the SSSI.

E. Preliminary comments on RSPB's draft information regarding the proposed compensation provision of a little tern island: Information regarding the proposed little tern island based on information supplied by RSPB and Natural England's comments on this information.

Kind regards,

Patrick

Patrick McKernan
Manager
Sussex and Kent team
Natural England
[redacted]

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We are here to secure a healthy natural environment for people to enjoy, where wildlife is protected and England's traditional landscapes are safeguarded for future generations

In an effort to reduce Natural England's carbon footprint, I will, wherever possible, avoid travelling to meetings and attend via audio, video or web conferencing

I am a contractual homeworker
Post should be directed to: Mail hub, Block B, Whittington Road, Worcester, WR5 2LQ
Please note new address from 25 Jan, 2016: Mail Hub, Natural England, County Hall, Spetchley Road, Worcester WR5 2NP

From: McKernan, Patrick (NE)
Sent: 22 June 2016 13:24
To: 'simon.davis@arun.gov.uk'
Cc: Seymour, James; Marlow, Angela (NE)
Subject: Further information for application no. P/97/15/PL - Pagham Harbour managed breach

<< File: NE Pagham further information response to Arun DC 22 June 16.pdf >>
Dear Simon

Please find attached Natural England's response to your consultation of 25 May regarding the further information for the managed breach of the shingle spit at Pagham Harbour (application no. P/97/15/PL).

Natural England is the statutory advisor for Appropriate Assessment and we look forward to being consulted on the local authorities' assessment in due course.

Kind regards,

Patrick

Patrick McKernan
Manager
Sussex and Kent team
Natural England
[redacted]

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you have received it in error you have no authority to use, disclose, store or copy any of its contents and you should destroy it and inform the sender. Whilst this email and associated attachments will have been checked for known viruses whilst within the Natural England systems, we can accept no responsibility once it has left our systems. Communications on Natural England systems may be monitored and/or recorded to secure the effective operation of the system and for other lawful purposes.

Site Name	Designation	Feature Name	Attribute	Option 1: unquantified target	Option 2: quantified target	Target Justification Options	Target Justification Free Text	Generic supporting and / or explanatory notes for the target	Reference Numbers	Site Specific Supporting Notes for the target	Site Specific Reference Numbers
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: morphology	Maintain the natural physical form and coastal processes that shape the seagrass bed.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		The coastal geomorphology will have overriding influences on all processes so should be maintained to support all the processes required.		It should be noted that the 'maintain' target allows for natural succession / cyclical change. The seagrass beds are located in West Pagham Harbour, centred around SZ 8727096170 [4214], [4775]. Wave and tidal energy within the harbour and around the seagrass beds is typically low due to Pagham's morphology as a tidal inlet. The inlet is fronted by a dynamic shingle beach complex which provides shelter from open-coast wave action [4490], [4491]. The coastal morphology of Pagham Harbour is complex and unique. It is almost impossible to predict the effect of such a dynamic coastline on highly variable habitats such as seagrass beds.	4490, 4491, 4214, 4775
Pagham Harbour	MCZ	Intertidal seagrass beds	Structure: sediment composition and distribution	Maintain the distribution of sediment composition types across the feature.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Zostera can colonise a wide variety of sediments, from sheltered gravel to sand or mud [2297; 2119; 2115], but requires a substrate soft enough for rhizomes to elongate and fasten. The presence and character of each bed is driven by a complex relationship between the levels of exposure. Sediment composition is important in determining the biological communities supported by the seagrass. There is a relationship between seagrass density and sediment composition that can vary across the seagrass bed (eg core area, or peripheral areas), increasing the diversity of communities present. Seagrass relies on sediment but the seagrass rhizomes also help to bind sediment and prevent erosion. A change to sediment composition can result in a loss or change to seagrass distribution and character. The distribution of sediment composition types should be used to characterise the site to avoid the need for long-term sediment coring, which could be destructive to this sensitive habitat.	2297; 2119; 2115	The seagrass beds are located in a larger expanse of intertidal mudflats and saltmarsh within Pagham Harbour [3002], [4844]. These habitats are actively maintained and protected by SPA and Ramsar designations.	3002, 4844
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: energy / exposure	Maintain the natural physical energy resulting from waves, tides and other water flows, so that the exposure does not cause alteration to the biotopes, and stability, across the habitat.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		The amount of energy received across the site significantly affects the communities present. Physical energy can be received through wave energy and / or tidal flow, and can be altered through human activity. Any such alterations to energy should be avoided [1007]. There is a complex relationship between hydrology and seagrass beds. Waves at the shoreline create high velocity environments that mobilise sediments and drive lower bed limits (for intertidal seagrass beds). Wave exposure and currents also influence the sediment grain size. Areas of high wave exposure have coarser sediments with lower nutrient concentrations, but are less anoxic [2116]. Exposure to tides and waves can create patchiness making more exposed areas of the bed more vulnerable [3251]. However, seagrass beds need current to survive. The lower limit of current velocities (ie the slowest) that seagrass can tolerate is determined by the physiology of the plant species, whereas the upper limit is purely mechanical [2116].	2116; 3251; 1007	The beds are located in West Pagham Harbour, centred around SZ 8727096170 [4214]. Wave and tidal energy within the harbour and around the seagrass beds are typically low due to Pagham's morphology as a tidal inlet. The inlet is fronted by a dynamic shingle beach complex which provides shelter from open-coast wave action [5067].	
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: physico-chemical properties	Maintain the natural physico-chemical properties of the water.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		The physico-chemical properties that influence habitats include salinity, pH and temperature. They can act alone or in combination to affect habitats and their communities in different ways, depending on species-specific tolerances. In coastal habitats they can vary widely and can influence the abundance, distribution and composition of communities at relatively local scales. Changes in any of these properties, as a result of human activities, may impact habitats and the communities they support. Although seagrass species in England demonstrate an ability to exist in a wide range of salinities, the relationship between salinity, colonisation and seed success are not known. Fresh water influence may determine seagrass distribution in the UK [2116]. It's recommended that the existing salinity levels at a site are maintained or restored to natural conditions, as far as possible. Many biological processes are temperature-dependent in seagrass beds (eg flowering and germination). At high temperatures photosynthesis and respiration increase, and if the temperature gets too high this causes a negative energy balance. At low temperatures growth reduces. Tolerances vary for each species and there are likely to be site-specific and seasonal requirements that are not well understood, so any changes to the natural temperature should be avoided [2116].	2116	Environmental Agency monitored a set of environmental variables in Pagham Lagoon and Pagham Harbour between the 2008 to 2013. The annual salinity ranged from 22 to 35. The average temperature ranged from 4ºC (winter) to 20ºC (summer) [4490].	4490
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: sediment contaminants	Restrict surface sediment contaminant levels to concentrations where they are not adversely impacting the infauna of the feature.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Various different contaminants are known to affect the species that live in or on the surface of sediments. These include heavy metals (mercury, arsenics, zinc, nickel, cadmium, etc), poly-aromatic hydrocarbons (PAHs), poly-chlorinated biphenyls (PCBs), organotins (TBT) and pesticides such as hexachlorobenzene. These can impact species sensitive to particular contaminants, degrading the community structure (eg heavy metals) and bioaccumulating within organisms, entering the marine food chain (eg PCBs) [1015].	2090; 1015	No site specific evidence.	
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: sedimentation rate	Maintain the natural rate of sediment deposition.		The target has been set due to a lack of evidence that the feature is being impacted by any anthropogenic activities.		The rate of sediment deposition is known to influence the status of habitats and / or their associated communities. Sedimentation can influence community composition, alter species growth rates and potentially impact reproductive success by affecting larval recruitment. The presence and character of seagrass beds are determined by a complex relationship between the exposure, sediment type and other parameters such as suspended sediment [2116]. Seagrasses rely on the presence of suitable sediment in order to colonise. Beds are usually in more sheltered areas where suspended sediments tend to settle, providing suitable conditions for colonisation. If suspended sediment is artificially high due to human activity, this may smother seagrass beds. A change in suspended sediment character can cause a direct loss of seagrass; it's also likely to change the bed shape and the communities it supports [2116].	2116	No site specific evidence.	
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: water quality - contaminants		Restrict aqueous contaminants to levels equating to (High / Good) Status (according to Annex VIII and X of the Water Framework Directive), avoiding deterioration from existing levels.	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Contaminants may impact the ecology of the Marine Protected Area by having a range of biological effects on different species within the habitat, depending on the nature of the contaminant [1004;3317;3318].	1004;3317;3318	No site specific evidence.	
		Intertidal	Supporting processes:		Maintain the dissolved oxygen (DO) concentration at levels equating to High Ecological	There is evidence from survey or monitoring that shows		Dissolved Oxygen (DO) levels affect the condition and health of features. Excessive nutrients and / or high turbidity can lead to a drop in DO, especially in warmer months. Low DO can have sub-lethal and lethal impacts on fish and infauna and epifauna communities [1034]. However, there's a significant amount of natural variation that needs to be considered [2212].		Measurements of oxygen in Pagham Lagoon and Pagham Harbour for the years 2008 to 2013 record dissolved oxygen concentration of between	

Pagham Harbour	MCZ	Intertidal seagrass beds	processes: water quality - dissolved oxygen		High Ecological Status (specifically ≥ 5.7 mg per litre (at 35 salinity) for 95 % of the year), avoiding deterioration from existing levels.	the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Seagrasses require a constant supply of oxygen to sustain aerobic metabolism in the roots and the leaves of the plant. Coastal sediments tend to be anoxic due to high levels of organic matter. Seagrasses have adapted to these conditions by using systems to diffuse oxygen from the water column. These systems of diffusion can be hindered by an increase in the speed and direction of water currents, or epiphyte coverage on the leaf blade [2116].	1034; 2212;2116	2.14mg/l (August reading and 15.4mg/l (April reading). Percentage of dissolved oxygen saturation varies throughout the year with a percentage saturation range of between 23% and 150% with no discernable seasonal pattern [4490].	4490
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: water quality - nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities. The aim is to seek no further deterioration or improve water quality [669;3831]. Seagrasses also require a number of inorganic nutrients. In addition to inorganic carbon for photosynthesis [2101], the most important are nitrogen and phosphorous.	2101; 669;3831	The risk of eutrophication across the site has been assessed as low using the Environment Agency's Weight of Evidence approach. This takes into account assessments of the Water Framework Directive opportunistic macroalgae and phytoplankton quality elements using the respective assessment tools. Therefore opportunistic macroalgal levels should be maintained so there is no adverse effect to the feature through limited algal cover (<15%) and low biomass (< 500 g m2) of macroalgal blooms in the available intertidal habitat, with area of available intertidal habitat affected by opportunistic macroalgae less than 15 %. There should also be limited (<5%) entrainment of algae in the	
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: water quality - turbidity	Maintain natural levels of turbidity (eg concentrations of suspended sediment, plankton and other material) across the habitat.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution or other matter washed into the sea from land sources. In coastal environments turbidity levels can rise and fall rapidly as a result of biological (eg plankton blooms), physical (eg storm events) or human (eg coastal development) factors. Prolonged changes in turbidity may influence the amount of light reaching the seabed, affecting the primary production and nutrient levels of the habitat's associated communities. Changes in turbidity may also have a range of biological effects on different species within the habitat, eg affecting their abilities to feed or breathe [2116; 2085].	2116;2085	No site specific evidence.	
Pagham Harbour	MCZ	Intertidal seagrass beds	Extent and distribution		Maintain the total extent of seagrass beds to above 3 ha (approximate minimum area observed 2007-2011), and spatial distribution as defined on the map.		NB: Having re-assessed the evidence, Natural England is minded to change this target to recover. This will be discussed with stakeholders prior to formal advice being published.	The extent describes the presence and area of the habitat. It's the total area of the habitat across the site as a whole, even where it's patchy. The distribution describes the more detailed location(s) and pattern of habitat across the site. The distribution will influence the component communities present, and also help increase the health and resilience of the feature. In the UK, Zostera is nationally scarce and a World Wildlife Fund marine health check reported that UK seagrass beds were in severe decline (estimated at between 25-49% over the last 25 years) [3252], although an update downgraded this status to degraded [2117]. Improvements in water quality are starting to counteract negative pressures [2116], but seagrass beds have not recovered to the extent reported before the large-scale die-offs from wasting disease in the 1920s and 1990s [2092]. The aim in Marine Protected Areas should be to recover its extent to known historical levels. Patchiness in the distribution of seagrass can be naturally induced, or driven by human activities. Increasing patchiness should be avoided across and within the seagrass bed. The core area is the most consistently dense area (with the least fragmentation), and is essential for long-term resilience and recovery. However, the more sparse edge areas are usually more vulnerable and may be patchy due to environmental pressures [2116; 3251].	2116; 3252; 2117; 2092; 3251	The main beds are located in West Pagham Harbour, centred around SZ 8727096170. Another transitory seagrass bed exists in the eastern part of the harbour. Both locations have been monitored by the Environment Agency annually since 2007 and contribute to the overall area recorded for Pagham harbour. There is significant inter-annual variation as the total area recorded ranged from 3ha and 8.62ha over these years [4214], [4775]. However, preliminary observations from the 2015 survey indicate that the beds have receeded to approximately 0.03ha, with patchyness in the core area of the main bed [4775]. The causes of this decrease are unknown and could be attributable to a number of factors, both natural and anthropogenic. Changing this target from 'maintain' to 'recover' would prioritise an investigation into this decrease of a nationally scarce and vital habitat.	4214, 4775
Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting habitat	Maintain the area of habitat that is likely to support the feature.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Seagrass is completely reliant on the supporting habitat, and the processes that influence it. The supporting habitat is likely to extend beyond the seagrass itself, but other limitations such as exposure and depth affect the extent [2116]. However, where seagrass has previously been damaged the extent could recover. Over time, supporting processes and exposure can change and improve, allowing opportunities for extent expansion or recovery. A buffer zone around seagrass beds will prevent the erosion of bed edges, and is advised. Activity around the edge of a bed may result in changes to the sediment composition and exposure, and erosion can occur leaving rhizomes uncovered and vulnerable, reducing the extent [2090].	2090; 2116	The seagrass beds are located in a larger expanse of intertidal mudflats and saltmarsh within Pagham Harbour [3002], [4844]. These habitats are actively maintained by the RSPB and are protected by SPA, Ramsar and SSSI designations. Under beneficial environmental conditions there is scope for the seagrass beds to expand back into the surrounding areas it occupied in 2011.	3002, 4844
Pagham Harbour	MCZ	Intertidal seagrass beds	Structure: biomass	Maintain the leaf / shoot density, length, percentage cover, and rhizome mat across the feature at natural levels (as far as possible), to ensure a healthy, resilient habitat.			NB: Having re-assessed the evidence, Natural England is minded to change this target to recover. This will be discussed with stakeholders prior to formal advice being published.	Biomass is the total amount of live vegetation associated with the seagrass bed. Leaf length and density are critical structural elements of each bed. Naturally, these can vary enormously and are influenced by the site-specific natural parameters, but both can be affected by human impacts. The parameters will also be very site-specific and therefore differ between beds [2116].	2116;2115;2087	Two species of seagrass have been observed in Pagham Habrour; Zostera noltii and Zostera angustifoli [4491]. Preliminary observations from the 2015 survey indicate that the beds have receeded to approximately 0.03ha, with patchyness in the core area [4214], [4775]. The causes of this decrease are unknown and could be attributable to a number of factors, both natural and anthropogenic. Changing this target from 'maintain' to 'recover' would prioritise an investigation into this decrease of a nationally scarce and vital habitat.	4491, 4214, 4775
Pagham Harbour	MCZ	Intertidal seagrass beds	Structure: Non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.		The target has been set due to a lack of evidence that the feature is being impacted by any anthropogenic activities.		Non-native species may become invasive and displace native organisms by preying on them or out-competing them for resources such as food, space or both. In some cases this has led to the loss of indigenous species from certain areas [3259]. A pathogen causes disease or illness to its host. Pathogens include bacteria, viruses, protozoa and fungi [3793].	3259; 3793	No site specific evidence.	
Pagham Harbour	MCZ	Intertidal seagrass beds	Structure: rhizome structure and reproduction	Maintain the extent and structure of the rhizome mats across the site, and conditions to allow for regeneration of seagrass beds.			NB: Having re-assessed the evidence, Natural England is minded to change this target to recover. This will be discussed with stakeholders prior to formal advice being published.	Zostera marina has the ability to reproduce via seed dispersal. Seeds are often apparent in the UK, although successful seed colonisation is rarely documented. Survey work has linked the colonisation of seeds to increased temperature [2101; 2116]. Colonisation could increase in the UK as temperatures rise. The majority of seagrass beds in the UK reproduce through the horizontal spread of a mat of rhizomes and roots. Leaves from Zostera species die back naturally in the winter and new shoots grow in the spring. If some shoots are lost during the summer they are likely to regrow the following year but if the rhizome mat is lost, recovery relies on its regrowth first. Seagrass is constantly regrowing, and to recover this growth should be at a rate that balances loss. The rate at which the seagrass (shoots, rhizome / roots) regrows varies from site to site, and can be hindered by other parameters. Recovery may occur within a season, or take years. There have been cases where growth has not occurred quickly enough to recover losses, leading to catastrophic losses of entire seagrass beds [2116].	2116;2101;2115;2087	Preliminary observations from the 2015 survey indicate that the beds have receeded to approximately 0.03ha [4214], [4775] with patchyness in the core area which may indicate damage to the rhizome mat. The causes of this decrease are unknown and could be attributable to a number of factors, both natural and anthropogenic. Changing this target from 'maintain' to 'recover' would prioritise an investigation into this decrease of a nationally scarce and vital habitat.	4214, 4775

Pagham Harbour	MCZ	Intertidal seagrass beds	Supporting processes: light levels	Maintain the natural light availability to the seagrass bed.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Light availability is important as photosynthesis is essential to seagrasses. Low light availability reduces respiration and productivity by the roots and rhizomes, lowering nutrient uptake. If light availability, and therefore carbon uptake [2087], is reduced by physical, biological or chemical parameters (eg epiphyte cover, storm events, poor water quality) lower depth limits are likely to be shallower and the extent limits of the seagrass beds reduced. Seagrass has light requirements an order of magnitude higher than other marine macrophytes, ranging from 2-37% of in-water surface irradiance (SI) [2099; 2100; 2116]. The high light requirements are a result of inefficient carbon uptake in seagrass [2087; 2116]. The critical thresholds for light availability for Zostera marina range from 11-37% of SI, but for Z. noltii it's only 2% SI.	2087; 2099; 2100; 2116;	No site specific evidence.	
Pagham Harbour	MCZ	Intertidal seagrass beds	Distribution: presence and spatial distribution of intertidal seagrass bed communities	Maintain the presence and spatial distribution of intertidal seagrass bed communities.			NB: Having re-assessed the evidence, Natural England is minded to change this target to recover. This will be discussed with stakeholders prior to formal advice being published.	A variety of communities make up the habitat. Listed component communities reflect the habitat's overall character and conservation interest. Communities are described as biotopes using EUNIS or the Marine Habitat Classification. Communities include, but are not limited to, those that are notable or representative of the feature. Representative communities include, for example, those covering large areas and notable communities include those that are rare, scarce or particularly sensitive to pressure. Changes to the spatial distribution of communities across the feature, could highlight changes to the overall feature [1016]. The communities supported by seagrass can vary enormously as seagrass can colonise any sediment from muddy to coarse. The unique sets of variables can support very different groups of infauna and epifauna communities.	1016	The seagrass is grazed by large populations of dark-bellied brent geese (Branta bernicla bernicla) and other herbivorous birds [4769]. The seagrass grows upon intertidal mud surrounded by saltmarsh, and so accordingly host rich invertebrate communities that support a large assemblage of piscivorous and carnivorous birds, some of which are protected by the SPA and Ramsar designations.	4769
Pagham Harbour	MCZ	Intertidal seagrass beds	Structure: presence and abundance of typical species	Maintain the abundance of listed typical species, to enable each of them to be a viable component of the habitat.				Natural England has included an attribute for the abundance of typical species for habitat features. Further work will be undertaken by Natural England to identify the individual species relevant for each habitat. This will be done in accordance with the criteria defined in the typical species paper [3255].	3255	No site specific evidence.	
Pagham Harbour	MCZ	Intertidal seagrass beds	Structure: species composition of component communities	Maintain the species composition of component communities.			NB: Having re-assessed the evidence, Natural England is minded to change this target to recover. This will be discussed with stakeholders prior to formal advice being published.	Species composition of communities includes a consideration of both the overall range of species present within the community, as well as their relative abundance. Species composition could be altered by human activities without changing the overall community type. Within each component community, species composition and population structure should be taken into consideration to avoid diminishing biodiversity and affecting ecosystem functioning within the habitat [1016].	1016	No site specific evidence.	
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting habitats: extent and distribution		Maintain the extent and spatial distribution of the following supporting habitats: Ferry Pool lagoon, 2ha.	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		The extent of supporting habitats captures the presence and area of the habitats that the species relies on. The distribution of supporting habitat will partially govern the distribution of the species, and maintaining or recovering the distribution of supporting habitats will help ensure the stability of this species. Supporting habitats may not be limited to those described in the target. The distribution of the lagoon sand shrimp is limited in England. This is likely to be due to a lack of suitable habitat, coupled with limited dispersal ability. This species is vulnerable to loss of its lagoon habitat from natural causes and as a result of reclamation, coastal defence, pollution and sea level rise, as well as inappropriate management [2191]. The lagoon sand shrimp appears to be associated with the alga Chaetomorpha linum , which may form extensive floating mats. Removal of these algal mats would remove the amphipod's food source. High levels of siltation may reduce light availability and therefore probably the abundance of the algae [2191]. Some saline lagoon habitat is unable to support the lagoon sand shrimp, due to the absence of seaweeds [1963].	2191;1963	The only known location of this species in the MCZ is in Ferry Pool lagoon, a small brackish lagoon situated to the north-east of the harbour [4489], [2975]. It is likely that loss of this population would result in local extinction.	4489, 2975
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Presence and spatial distribution of the species	Maintain the presence and spatial distribution of the species.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		The presence describes the species occurrence, with the spatial distribution providing a more detailed overview of the location(s) and pattern of occurrence within a site. It's important to consider the various life stages of a species as this may influence its distribution. Disturbance caused by human activities should not adversely affect the species. In the UK the lagoon sand shrimp is limited to sheltered, shallow, brackish water habitats with a variety of sediments ranging from organic muds to shingle with various mixtures of sand and silt-clay. The species appears to be associated with the algae Chaetomorpha linum, which may form extensive floating mats. In the UK lagoons are shallow and the species is found to a maximum depth of 2-3 m. Its UK distribution is predominantly the south coast of England, a few sites in East Anglia, and one site in the Humber, Severn Estuary and South Wales. This species has been lost from at least 5 lagoons in the UK in the last 30 years [1963].	2191;1963	Within this MCZ the species is only found in Ferry Pool lagoon, located in the western side of the main harbour. Ferry Pool is a small, shallow water body above mean high water, and remains connected to the main harbour by a small sluice pipe running under the adjacent B1245 road. Due to the pipe's importance in mediating environmental conditions vital to the shrimp, and in maintaining an ecological connection to Pagham Harbour, it is included in the MCZ [520], [761].	520, 761
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Population: population size	Maintain the population size within the site.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Population size is the number of individuals within a population that are able to contribute to the species viability at a local, national and bio-geographic scale. Population size relates to the abundance of a species. It should include all the populations of a species within the site. Abundance may vary spatially and temporally. The lagoon sand shrimp tolerates reduced salinity and can be locally abundant in brackish pools and saline lagoons [1954].	1954	The only known location of this species in the area is in Ferry Pool lagoon [4489]. The size of the population is unknown. However, due to lack of connection with other populations, it is likely that loss of this population would result in local extinction.	4489

Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Population: recruitment and reproductive capability	Maintain the reproductive and recruitment capability of the species.		The target has been set due to a lack of evidence that the feature is being impacted by any anthropogenic activities.		Recruitment and reproductive capability reflect the health and success of the population in terms of maintaining and / or restoring numbers. A reduction in the availability of individuals able to successfully reproduce, and survival rates, may impact the overall size and age-structure of the population. There is no larval stage in the lagoon sand shrimp and development is direct, with young being miniature adults. Studies in Gilkicker lagoons found that this species reproduced throughout the year – the largest brood size was 90 embryos. Brood sizes peaked in the spring and early summer and then dropped during the late summer and winter, which could be due to temperature and salinity conditions. The fact there is no larval stage may mean potential dispersal is limited. In France, life span varies from 48-408 days according to the water temperature when born [2055]. Those born in the winter develop 4-5 times slower than those born in the summer. The overall sex ratio in the lagoon sand shrimp is relatively stable all year, but the proportion of reproductively mature females in the population does vary, being lowest in the winter and highest in spring and autumn, when the number of brooding females is at its highest. The juvenile proportion of the population increases between September and January [1954]. Sexual dimorphism is seen and males can reach a larger size than females. Brood size increases with female size [1954].	2055; 1954	The only known location of this species in the MCZ is in Ferry Pool lagoon [4489]. It is likely that loss of this population would result in local extinction.	4489
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting processes: sediment movement and hydrodynamic regime	Maintain all hydrodynamic and physical conditions such that natural water flow and sediment movement is not significantly altered or constrained.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		Sediment movement is influenced by tide and wave driven water flow. Natural movement of water and sediment should not be hindered. Hydrodynamic conditions include the speed and direction of wave and tidal currents, seabed shear stress and wave exposure. Alterations to these processes could affect species presences and distribution. The lagoon sand shrimp lives in lagoons, typically to depths of around 2-3 m [2191] where there is low water flow. An increase in water flow rate or exposure could cause the species to be washed away. Reduced water levels would cause the species to be affected by desiccation during emersion. The algae on which it feeds may also dry out [2191]. While the lagoon sand shrimp is thought to be able to move up through new sediment and thereby tolerate smothering, disturbance and deposition of new sediment, this could lead to a removal of the species algal food source. High levels of siltation may reduce light availability and therefore probably the abundance of the species food source, the alga Chaetomorpha linum [2191].	2191	Seawater exchange in Ferry Pool lagoon is limited as all water exchange occurs via a small pipe [520]. Due to this and the small size of the lagoon the site is very vulnerable to dessication. The pipe also limits sediment removal rates and so there is heightened risk of smothering in the event of a large sedimentation event.	520
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting processes: water quality: contaminants		Restrict aqueous contaminants to levels equating to (High / Good) Status (according to Annex VIII and X of the Water Framework Directive), avoiding deterioration from existing levels.	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Contaminants may have a range of biological effects on the species, depending on the nature of the contaminant [1004], [3317], [3318]. The lagoon sand shrimp is sensitive to contamination by synthetic compounds and hydrocarbons [2191].	2191; 1004; 3317; 3318	No site specific evidence.	
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting processes: water quality: nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities. The aim is to seek no further deterioration or improve water quality [669], [3831]. The lagoon sand shrimp is very sensitive to organic enrichment and disturbance, and is usually present only in unpolluted conditions [1921]. The species feeds primarily on Chaetomorpha . Changes to nutrient levels may result in changes in the abundance of Chaetomorpha .	1921; 669; 3831	The risk of eutrophication across the site has been assessed as low using the Environment Agency's Weight of Evidence approach. This takes into account assessments of the Water Framework Directive opportunistic macroalgae and phytoplankton quality elements using the respective assessment tools. Therefore opportunistic macroalgal levels should be maintained so there is no adverse effect to the feature through limited algal cover (<15%) and low biomass (< 500 g m2) of macroalgal blooms in the available intertidal habitat, with area of available intertidal habitat affected by opportunistic macroalgae less than 15 %. There should also be limited (<5%) entrainment of algae in the underlying sediment (all accounting for seasonal variations and fluctuations in	
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Structure: Non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Non-native species may become invasive and displace native organisms by preying on them or out-competing them for resources such as food, space or both. In some cases this has led to the loss of indigenous species from certain areas [3259]. A pathogen causes disease or illness to its host. Pathogens include bacteria, viruses, protozoa and fungi [3793].	3259; 3793	No site specific evidence.	
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting processes: physico-chemical properties	Maintain the natural physico-chemical properties of the water.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been		The physico-chemical properties that influence the species include salinity, pH and temperature. These abiotic factors can affect the species in different ways depending on species-specific tolerances. Temperature and salinity are closely linked and can act either alone or in combination and can ultimately determine the success of a population, most notably in coastal habitats. Changes in any of these properties, as a result of human activity, may also impact the supporting habitats and the food favoured by the species. The lagoon sand shrimp tolerates reduced salinity and can be locally abundant in brackish pools and saline lagoons [1954]. However, the preferred salinity range for this species is 15-40 [403]. It's found in hyper and hyposaline waters	1954; 403	Lagoons are characterised by low levels of water exchange, Seawater exchange in Ferry Pool lagoon is especially limited in that all seawater flow occurs via a small pipe, so large fluctuations in temperature and salinity are expected to occur [520]. The Environmental Agency monitered a set of environmental variables in Pagham Lagoon and Pagham Harbour between the 2008 to 2013. The annual salinity ranged from 22 to 35. The average temperature ranged from 4ºC (winter) to 20ºC (summer). Ferry pool lagoon is expected to have a wider range in both variables due to low water circulation [4490].	520, 4490
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting habitats: sediment composition and distribution	Maintain the distribution of sediment composition across the supporting habitats, allowing for natural succession / cyclical change, and input of fresh sediment to maintain the lagoon regime.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Sediment character is instrumental in determining the biological communities and species present. Littoral sediments range from highly stable mudflats and saltmarshes, to highly mobile shingle and sand beaches. They are subject to a range of deposition and erosion processes, which can be influenced by human activities. Most littoral sediments stabilise over time so maintaining the sediment composition supports the natural succession of the habitats and communities. Where they are subject to constant (net) erosion, the natural processes may be adversely affected. Detailed studies of the distribution of the DeFolin's lagoon snail in the Fleet and Pagham have shown that highest population densities occur only in loose, undisturbed, uncompacted, aerobic shingle. Any activities that could compact the sediment, or turn over the upper layers of loose shingle, thus exposing the interstitial communities to drying effects, may impact this species.		The Church Norton shingle habitat is already subject to management by the RSPB under the existing SPA protection afforded to the nesting sites of little terns [4774].	4774
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting habitats: extent and distribution	Maintain the extent and spatial distribution of the following supporting habitats: saline lagoon; loose shingle		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		The extent of supporting habitats captures the presence and area of the habitats that the species relies on. The distribution of supporting habitat will partially govern the distribution of the species, and maintaining or recovering the distribution of supporting habitats will help ensure the stability of this species. Supporting habitats may not be limited to those described in the target. The integrity of the lagoon needs to be maintained in a natural and functional state. Reduction / disintegration of the lagoon bank would result in loss of water, and thus supporting subtidal habitat, or reduced isolation / division from adjacent freshwater sources.		While other MCZs provide protection to their sites below the mean high water (MHW) line, in Pagham Harbour the DeFolin's lagoon snail colonies are found higher up the shingle banks on Church Norton Spit [583], [639]. These parts of the spit were included in the MCZ to give protection to the Defolin snail supporting habitat, as the loose shingle is the most important habitat to the snail [520]. The rapid natural evolution of this coastline could result in large amounts of variation in the supporting habitat extent and distribution. Additionally sea level rise has the potential to significantly impact this feature.	583, 639, 520

Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Presence and spatial distribution of the species	Maintain the presence and spatial distribution of the species.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		The presence describes the species occurrence, with the spatial distribution providing a more detailed overview of the location(s) and pattern of occurrence within a site. It's important to consider the various life stages of a species as this may influence its distribution. Disturbance caused by human activities should not adversely affect the species. The distribution of the DeFolin's lagoon snail is restricted to lagoonal shingle, where seawater percolates through the shingle habitat that it prefers. This species is recorded from 3 localities along the south coast of England: Fleet Lagoon, Pagham Harbour and Lydd [642], [580], [583].	642;580;583	The size and nature of this snail make it difficult to survey. The methods to quantify this species are very invasive and usually damaging as they require removal of the species from the habitat [583],[639]. Only some areas In Pagham have been surveyed, giving an apparently patchy distribution on Church Norton Spit. It is important to note that the full spatial extent of this population within the local shingle habitats remain unknown. This species is often found associated with other molluscs. In Pagham an association was observed between the Defolins lagon snail and the larger, more detectable 'looping snail' Truncatella subcylindrica [583],[639].	583, 639
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Population: population size	Maintain the population size within the site.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Population size is the number of individuals within a population that are able to contribute to the species viability at a local, national and bio-geographic scale. Population size relates to the abundance of a species. It should include all the populations of a species within the site. Abundance may vary spatially and temporally. Population densities of the DeFolin's lagoon snail have been recorded in sites such as the Fleet in Dorset and Pagham in West Sussex in the range 100-16,000 per m^2 where environmental conditions are optimal [642], [580], [583].	642;580;583	No site specific evidence.	
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Population: recruitment and reproductive capability	Maintain the reproductive and recruitment capability of the species.		The target has been set due to a lack of evidence that the feature is being impacted by any anthropogenic activities.		Recruitment and reproductive capability reflect the health and success of the population in terms of maintaining and / or restoring numbers. A reduction in the availability of individuals able to successfully reproduce, and survival rates, may impact the overall size and age-structure of the population. Little is known about the recruitment and reproductive capabilities of the DeFolin's lagoon snail. However, maintaining suitable habitat conditions and managing human pressures will help maintain capabilities. A thriving population of the DeFolin's lagoon snail should include the full range of living life stages, from juveniles to adult shells [642], [580], [583], [581]. Survey work in the Fleet Lagoon (Dorset) and Pagham (West Sussex) has recorded all life stages in optimal habitat, as well as recently dead adult shells and other unsuccessful life stages.	642;580;583;581	No site specific evidence.	
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting processes: sediment movement and hydrodynamic regime	Maintain all hydrodynamic and physical conditions such that natural water flow and sediment movement is not significantly altered or constrained.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Sediment movement is influenced by tide and wave-driven water flow. Natural movement of water and sediment should not be hindered. Hydrodynamic conditions include the speed and direction of wave and tidal currents, seabed shear stress and wave exposure. Alterations to these processes could affect species presences and distribution. Maintaining water flow through shingle habitat prevents accumulation of fine sediment. Only very low numbers of live snails and occasional dead shells and shell fragments are found in compacted sediments [749], [645], [580], [583]. Only a few sites are known to support the species. The Fleet sea-level variation is not on a regular tidal basis, but does have a fortnightly component and tidal range of 0.03-0.18 m. At Pagham and Lydd there is a lag between high water within and outside the lagoon [749], [645]. The DeFolin's lagoon snail prefers habitats that provide shelter from wave action. Lagoon habitats, by their very nature, are sheltered from wave action. Channels in the Fleet, adjacent to the highest population densities of the DeFolin's lagoon snail, have slight tidal velocities (<0.5 knots). There's no information on tidal streams at sites at Pagham and Lydd [645].	580;583;749;645	Pagham Harbour is a tidal inlet fronted by a dynamic shingle beach complex (Church Norton spit) which provides shelter from open-coast wave action [5067]. The harbour side of this spit banks onto a saline lagoon, forming the very specific conditions required by this species are found [583], [639].	583, 639, 5067
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting processes: water quality: contaminants		Restrict aqueous contaminants to levels equating to (High / Good) Status (according to Annex VIII and X of the Water Framework Directive), avoiding deterioration from existing levels.	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Contaminants may have a range of biological effects on the species, depending on the nature of the contaminant [1004], [3317], [3318].	1004; 3317; 3318	No site specific evidence.	
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting processes: water quality: nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities. The aim is to seek no further deterioration or improve water quality [669], [3831]. Eutrophication can lead to accumulation of dense overgrowth of filamentous algae such as Ectocarpaceae resulting in the development of anaerobic conditions (lack of oxygen) within the shingle interstitial space. DeFolin's lagoon snail occurs in good numbers in the shingle habitat when there are aerobic conditions.	669; 3831	The risk of eutrophication across the site has been assessed as low using the Environment Agency's Weight of Evidence approach. This takes into account assessments of the Water Framework Directive opportunistic macroalgae and phytoplankton quality elements using the respective assessment tools. Therefore opportunistic macroalgal levels should be maintained so there is no adverse effect to the feature through limited algal cover (<15%) and low biomass (< 500 g m2) of macroalgal blooms in the available intertidal habitat, with area of available intertidal habitat affected by opportunistic macroalgae less than 15 %. There should also be limited (<5%) entrainment of algae in the underlying sediment (all accounting for seasonal variations and fluctuations in growth). Phytoplankton levels should be maintained above a WFD assessment	
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Structure: Non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.		The target has been set due to a lack of evidence that the feature is being impacted by any anthropogenic activities.		Non-native species may become invasive and displace native organisms by preying on them or out-competing them for resources such as food, space or both. In some cases this has led to the loss of indigenous species from certain areas [3259]. A pathogen causes disease or illness to its host. Pathogens include bacteria, viruses, protozoa and fungi [3793].	3259; 3793	No site specific evidence.	
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting processes: physico-chemical properties	Maintain the natural physico-chemical properties of the water.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		The physico-chemical properties that influence the species include salinity, pH and temperature. These abiotic factors can affect the species in different ways depending on species-specific tolerances. Temperature and salinity are closely linked and can act either alone or in combination and can ultimately determine the success of a population, most notably in coastal habitats. Changes in any of these properties, as a result of human activity, may also impact the supporting habitats and the food favoured by the species. Little is known about the specific pH tolerances of the DeFolin's lagoon snail. Data obtained by the Environment Agency between 2002-2008 in the Western Fleet (Dorset), where this species is found, indicates a pH range from 7.5-10. However, coastal saline lagoons show spatial and temporal variations in pH. The species can tolerate a wide range of salinities (12-35 ppt) and can benefit from fluctuating salinities through reduced competition [748], [645]. The species can also tolerate a wide daily and annual temperature range (eg annual range of 0-30 ^{o}C) [645], [748], [2189].	748;645;2189	Data obtained by the Environmental Agency between 2008 - 2013 in Pagham Lagoon and Pagham Harbour found the annual salinity ranged from 22 to 35, and the average annual temperature ranged from 4ºC (winter) to 20ºC (summer) [4490].	4490

Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting processes: water quality: turbidity	Maintain natural levels of turbidity (eg concentrations of suspended sediment, plankton and other material) in areas where this species is, or could be present.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution or other matter washed into the sea from land sources. In coastal environments turbidity levels can rise and fall rapidly as a result of biological (eg plankton blooms), physical (eg storm events) or human (eg coastal development) factors. Prolonged increases in turbidity could affect the ability of the species to feed and respire. Turbid, sediment-laden water should be avoided as this may result in infilling of interstitial spaces of the shingle habitat necessary for the species to live in.		No site specific evidence.	
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting habitats: structure of supporting habitats	Maintain the structure of the supporting habitats so that the lagoon is not compromised.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		The maintenance of lagoon banks, including the isolating barrier, in a natural and functional state is key to maintaining the lagoon feature and the water as a supporting habitat for this species. Reduction / disintegration of the lagoon bank would result in loss of water, and thus supporting and structural subtidal habitat, or reduced isolation / division from adjacent freshwater sources.		This species requires very specific habitat conditions to survive: seawater percolating through uncompacted, aerobic shingle [583], [639]. It should be noted that the 'maintain' target allows for natural succession / cyclical change.	583, 639
Pagham Harbour	MCZ	DeFolin's lagoon snail (Caecum armoricum)	Supporting processes: water quality: dissolved oxygen		Maintain the dissolved oxygen (DO) concentration at levels equating to High Ecological Status (specifically ≥ 5.7 mg per litre (at 35 salinity) for 95 % of the year), avoiding deterioration from existing levels.	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Dissolved Oxygen (DO) levels affect the condition and health of species. Excessive nutrient load and / or high turbidity can lead to a drop in DO, especially in warmer months. Low DO can have sub-lethal and lethal effects on fish, and infauna and epifauna communities. However, there's a significant amount of natural variation that needs to be considered [1034], [2212]. Lagoon environments frequently have high macroalgal production, which can result in anoxic (lack of oxygen) conditions on the lagoon floor.	1034; 2212	Measurements of oxygen in Pagham Lagoon and Pagham Harbour for the years 2008 to 2013 record dissolved oxygen concentration of between 2.14mg/l (August reading and 15.4mg/l (April reading). Percentage of dissolved oxygen saturation varies throughout the year with a percentage saturation range of between 23% and 150% with no discernable seasonal pattern [4490].	4490
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting habitats: sediment composition and distribution	Maintain the distribution of sediment composition across the lagoon, allowing for natural succession / cyclical change, and input of fresh sediment to maintain the lagoon regime.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		Sediment character is instrumental in determining the biological communities and species present. The lagoon sand shrimp occurs in mud, muddy sand and sandy mud. The species is highly sensitive to substratum loss and recovery would be low, due to its limited distribution [2191].	2191	The small size of Ferry Pool lagoon and the limited exchange rate through the pipe means that the sediment composition is relatively stable.	
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Structure and function: biological connectivity	Maintain connectivity of the habitat within sites and the wider environment to ensure dispersal and recruitment.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Connectivity is the extent to which populations in different parts of a species' range are linked by the movement of eggs, larvae or other propagules, juveniles or adults [3260]. The lagoon sand shrimp is highly sensitive to poor connectivity. In some lagoonal systems, particularly in man-made systems, the lagoons are interconnected. Low dispersal potential (adult dispersal ability is between 100-1000 m) coupled with low fecundity makes this species the most sensitive amphipod to loss of connectivity [1931]. Isolation of pools may lead to fragmentation of populations and reduces the likelihood of recolonisation if a population is lost.	1931; 3260	Although there are other saline lagoons in the MCZ, all records of this species are from in Ferry Pool lagoon [4489]. The pipe to the main harbour maintains the brackish salinity of Ferry Pool lagoon, but there is no evidence to indicate whether this pipe also maintains a wider biological connection by transporting individuals to and from the lagoon. Due to lack of records in the surrounding area it is likely that loss of this population would result in local extinction.	4489
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting processes: water quality: turbidity	Maintain natural levels of turbidity (eg concentrations of suspended sediment, plankton and other material) in areas where this species is, or could be present.		The target has been set in accordance with the MCZ General Management Approach, based on application of the vulnerability assessment, from the time of designation. The GMA has been tailored to specific attributes according to the likely impacts.		Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution or other matter washed into the sea from land sources. In coastal environments turbidity levels can rise and fall rapidly as a result of biological (eg plankton blooms), physical (eg storm events) or human (eg coastal development) factors. Prolonged increases in turbidity could affect the ability of the species to feed and respire. While the lagoon sand shrimp is thought to be able to move up through new sediment and thereby tolerate smothering, disturbance and deposition of new sediment, this could lead to a removal of the species algal food source. The lagoon sand shrimp feeds on the alga Chaetomorpha , which is dependent on light availability for photosynthesis. Turbidity would reduce light availability and therefore probably the abundance of Chaetomorpha [2191].	2191	No site specific evidence.	
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting habitats: structure of supporting habitats	Maintain the structure of the supporting habitats so that the lagoon is not compromised.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		The maintenance of lagoon banks, including the isolating barrier, in a natural and functional state are key to maintaining the lagoon feature and the water as a supporting habitat for this species. Reduction / disintegration of the lagoon bank would result in loss of water, and thus supporting and structural subtidal habitat, or reduced isolation / division from adjacent freshwater sources.		No site specific evidence.	
Pagham Harbour	MCZ	Lagoon sand shrimp (Gammarus insensibilis)	Supporting processes: water quality: dissolved oxygen		Maintain the dissolved oxygen (DO) concentration at levels equating to High Ecological Status (specifically ≥ 5.7 mg per litre (at 35 salinity) for 95 % of the year), avoiding deterioration from existing levels.	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Dissolved Oxygen (DO) levels affect the condition and health of species. Excessive nutrient load and / or high turbidity can lead to a drop in DO, especially in warmer months. Low DO can have sub-lethal and lethal effects on fish, and infauna and epifauna communities. However, there's a significant amount of natural variation that needs to be considered [1034], [2212]. Lagoon environments frequently have high macroalgal production, which can result in anoxic conditions on the lagoon floor.	1034; 2212	Measurements of oxygen in Pagham Lagoon and Pagham Harbour for the years 2008 to 2013 record dissolved oxygen concentration of between 2.14mg/l (August reading and 15.4mg/l (April reading). Percentage of dissolved oxygen saturation varies throughout the year with a percentage saturation range of between 23% and 150% with no discernable seasonal pattern [4490].	4490

Site Name	Designation	Feature Name	Attribute	Option 1: unquantified target	Option 2: quantified target	Target Justification Options	Target Justification Free Text	Generic supporting and / or explanatory notes for the target	Reference UID	Site specific supporting notes for the target	Site Specific Reference UIDs
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: food availability within intertidal mudflat	Maintain a high cover/abundance of preferred food plants (e.g. Zostera, Enteromorpha, Ulva lactuca).		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target is included because the availability of an abundant food supply is critically important for adult fitness and survival and the overall sustainability of the population. As a result, inappropriate management and direct or indirect impacts which may affect the distribution, abundance and availability of prey may adversely affect the population.	[1233;94;104]	Wintering dark bellied brent geese come to Pagham and other south coast harbours to feed on the Zostera and green algae which grow in the harbour and on the surface of the mudflats. The SPA contains 116.76 ha of intertidal mud of which seagrass beds fluctuate between 3 - 8.6 Ha.There are two areas within Pagham Harbour where seagrass bed appear; a large area within the western part of a harbour and a smaller transient bed in the eastern part (please see map in Magic). The algae in Pagham, mainly Ulva lactuca and Enteromorpha spp., are of primary importance as a food source and the large population of brent geese has led to a decline in the amount of green algae in the harbour. This has subsquently led to the use of the surrounding agricutural land outside the SPA as a food source	3002,4844, 4214, 4775, 4769
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: water quality: nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities and hence adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. The aim is to seek no further deterioration or improve water quality. However, there is significant natural variability that should be considered. Targets will be specific to the type of supporting habitat in the site. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.		The risk of eutrophication across the site has been assessed as low using the Environment Agency's Weight of Evidence approach. This takes into account assessments of the Water Framework Directive opportunistic macroalgae and phytoplankton quality elements using the respective assessment tools. Adverse effects to integrity should be avoided. Therefore opportunistic macroalgal levels should be maintained so there is no adverse effect to the feature through limited algal cover (<15%) and low biomass (< 500 g m2) of macroalgal blooms in the available intertidal habitat, with area of available intertidal habitat affected by opportunistic macroalgae less than 15 %. There should also be limited (<5%) entrainment of algae in the underlying sediment (all accounting for seasonal variations and fluctuations in growth). Phytoplankton levels should be maintained above a WFD assessment tool score of 0.6, where there is only a minor (a) decline in species richness, and (b) disturbance to the diatom-dinoflagellate succession in the spring bloom compared to reference condition	
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: water quality: turbidity	Maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) across the habitat.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution or other matter from land sources. Turbidity levels can rise and fall rapidly as a result of biological (eg plankton blooms), physical (eg storm events) or human (eg development) factors. Prolonged changes in turbidity may influence the amount of light reaching supporting habitats, affecting the primary production and nutrient levels of the habitat's associated communities. Changes in turbidity may also have a range of biological effects on different species within the habitat, eg affecting their abilities to feed or breathe. A prolonged increase in turbidity is indicative of an increase in suspended particulates. This has a number of implications for the aquatic/marine environment, such as affecting fish health, clogging the filtering organs of suspension feeding animals and affecting sedimentation rates. This in turn can adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.			4772
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Non-breeding population: abundance		Maintain the size of the non-breeding population at a level which is above 3045, whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This will sustain the site's population and contribute to a viable local, national and bio-geographic population. Due to the mobility of this feature and the dynamic nature of population change, the target-value given for the population size of this feature is considered to be the minimum standard for conservation/restoration measures to achieve. This minimum-value may be revised where there is evidence to show that a population's size has significantly changed as a result of natural factors or management measures and has been stable at or above a new level over a considerable period (generally at least 10 years). The values given here may also be updated in future to reflect any strategic objectives which may be set at a national level for this feature. Given the likely fluctuations in numbers over time, any impact-assessments should focus on the current size of the site's population, as derived from the latest known or estimated level established using the best available data. This advice accords with the obligation to avoid deterioration of the site or significant disturbance of the species for which the site is classified, and seeks to avoid plans or projects that may affect the site giving rise to the risk of deterioration. Similarly, where there is evidence to show that a feature has historically been more abundant than the stated minimum target and its current level, the ongoing capacity of the site to accommodate the feature at such higher levels in future should also be taken into account. Maintaining or restoring bird abundance depends on the suitability of the site. However, factors affecting suitability can also determine other demographic rates of birds using the site including survival (dependent on factors such as body condition which influences the ability to breed or make foraging and / or migration movements) and breeding productivity. Adverse anthropogenic impacts on either of these rates may precede changes in population abundance (e.g. by changing proportions of birds of different ages) but eventually may negatively affect abundance. These rates can be measured / estimated to inform judgements of likely impacts on abundance targets. Unless otherwise stated, the population size will be that measured using standard methods such as peak mean counts or breeding surveys. This value is also provided recognising there will be inherent variability as a result of natural fluctuations and margins of error during data collection. Whilst we will endeavour to keep these values as up to date as possible, local Natural England staff can advise whether the figures stated are the best available.		For the classification in 1988, the SPA non-breeding population was given as 3045 individuals (five year peak mean 1980/1981 to 1985/1986) which represent 2% of the European Wintering popultion. The number of individuals on the site has declined slightly since classification with a more recent figure of 2573 individuals.	4771, 4179,
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: water quality: contaminants	Restrict aqueous contaminants to levels equating to [Good/High] Status, avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Contaminants may have a range of biological effects on different species within the supporting habitat, depending on the nature of the contaminant. This in turn can adversely affect the availability of bird breeding, rearing, feeding and roosting habitats. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.			
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: vegetation characteristics for feeding	Maintain the extent and distribution of predominantly short (<10 cm) grassland swards in areas used for feeding		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		The height, cover, variation and composition of vegetation are often important characteristics of habitats supporting this feature which enables successful concealment/roosting/foraging/feeding and/or displaying. Many bird species will have specific requirements that conservation measures will aim to maintain, for others such requirements will be less clear. Activities that may directly or indirectly affect the vegetation of supporting habitats and modify these characteristics may adversely affect the feature.	[2587;2500;2588;2589;33;94;104]		4774
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: landscape	Maintain open and unobstructed terrain and overall field sizes within at least 0.5km of roosting and feeding areas.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This feature is known to favour large areas of open terrain, largely free of obstructions, in and around its roosting and feeding areas. Often there is a need to maintain an unobstructed line of sight within feeding or roosting habitat to detect approaching predators, or to ensure visibility of displaying behaviour. An open landscape may also be required to facilitate movement of birds between the SPA and any off-site supporting habitat.	[2500;33]		
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: hydrology/flow within intertidal	Maintain the availability of fresh water on mudflats within feeding and resting areas.				Changes in source, depth, duration, frequency, magnitude and timing of water supply or flow can have important implications for this feature. Such changes may affect the quality and suitability of habitats used by birds for drinking, preening, feeding or roosting. Unless these have already been undertaken, further site-specific investigations may be required to fully inform conservation measures for this feature and/or the likelihood of impacts on this attribute.	[14]	The harbour serves as an important drainage basin for freshwater from 5,000 ha of surrounding low-lying farmland. Broad Rife, Bremere Rife and Pagham Rife are all classified as 'Main Rivers' and drain into the harbour. Water from Broad Rife is pumped by the EA into the harbour at Ferry pumping station when levels are high under an automatic system . Bremere Rife, Pagham Rife, Red Barn Ditch, and a small sluice on the west side discharge by gravity at low tide through flap valves.	4774

Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: water quality: dissolved oxygen	Maintain the dissolved oxygen (DO) concentration to levels equating to High Ecological Status avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Dissolved Oxygen (DO) levels affect the condition and health of supporting habitats. Excessive nutrients and/or high turbidity can lead to a drop in DO, especially in warmer months. Low DO can have sub-lethal and lethal impacts on fish and infauna and epifauna communities [1034] and hence can adversely affect the availbility and suitability of bird breeding, rearing, feeding and roosting habitats. However, there is a significant amount of natural variation that should be considered. Targets will be specific to the types of supporting habitat in the site. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.		Measurements of oxygen in Pagham Lagoon and Pagham Harbour for the years 2008 to 2013 record dissolved oxygen concentration of between 2.14mg/l (August reading and 15.4mg/l (April reading). Percentage of dissolved oxygen saturation varies throughout the year with a percentage saturation range of between 23% and 150% with no discernable seasonal pattern	4490
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: food availability within saltmarsh	Maintain a high cover/abundance of preferred food plants (e.g. Spergularia, Puccinellia, Triglochin, Aster trifolium, Plantago, Salicornia spp).		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target is included because the availability of an abundant food supply is critically important for adult fitness and survival and the overall sustainability of the population. As a result, inappropriate management and direct or indirect impacts which may affect the distribution, abundance and availability of prey may adversely affect the population.	[2573;1233;33;104]	Dark- bellied brent geese feed on the saltmarsh plants as an alternative food source to the surrounding arable and pasture fields, when food supplies on the mudflats has depleted. The higher areas of saltmarsh provide a safe haven for brent geese from the tide. The extent of saltmarsh present in Pagham Harbour is 98.58 ha suggesting that there is sufficient food availability, although the current coverage of food plants is unknown.	4844, 2914
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: extent and distribution of supporting non-breeding habitat		Maintain the extent and distribution of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of the non-breeding/wintering period (moulting, roosting, loafing, feeding) at: Annual vegetation of driftline/shingle: 44.8ha Freshwater and coastal grazing marsh: 81.71 ha Intertidal coarse sediment:43.83ha Intertidal mud: 116.76 ha Intertidal sand and muddy sand 1.83ha Intertidal seagrass beds to above 3ha (above the minimum area of seagrass according to annual variation).	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This target may apply to supporting habitat which also lies outside the site boundary.		Wintering dark bellied brent geese come to Pagham and other south coast harbours to feed on the eelgrass and green algae which grow in the harbour and on the surface of the mudflats. The SPA contains 116.76 ha of intertidal mud of which seagrass bed extent fluctuates between 3 - 8.6 ha. The main seagrass bed is located in West Pagham Harbour, centred around SZ 8727096170. Another transitory seagrass bed exists in the eastern part of the harbour. The surrounding intertidal mudflats also contain green algae which are of primary importance as a food source to the brent geese. The large number of geese has led to a decline of green algae growing in the harbour. Alternative sources of food (which are typically used when the mudflats have been depleted) are the surrounding saltmarshes and fields. The larger areas of saltmarsh also provide a safe haven from the tide. The extent of saltmarsh present in Pagham Harbour is 98.58 ha, and the extent of coastal grazing marsh is 81.71 ha, suggesting that there is sufficient food availability, although the current coverage of food plants is unknown.	3002, 4844, 2914, 4770, 4214, 4775, 5046, 5045
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: disturbance caused by human activity	Restrict the frequency, duration and / or intensity of disturbance affecting roosting, foraging, feeding, moulting and/or loafing birds so that they are not significantly disturbed		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		The nature, scale, timing and duration of some human activities can result in the disturbance of birds at a level that may substantially affect their behaviour, and consequently affect the long-term viability of the population. Such disturbing effects can for example result in changes to feeding or roosting behaviour, increases in energy expenditure due to increased flight and desertion of supporting habitat (both within or outside the designated site boundary where appropriate). This may undermine successful feeding and/or roosting, and/or may reduce the availability of suitable habitat as birds are displaced and their distribution within the site contracts. Disturbance associated with human activity may take a variety of forms including noise, light, sound, vibration, trampling, presence of people, animals and structures.	[72;11;89]	Pagham Harbour being a small area means that the birds using this site are more susceptible to disturbance. This site has open access over the shingle beach area, which includes, along with other species, brent geese feeding and roosting areas. The public footpath and open access areas are regularly used by walkers, bird watchers, dog walkers, anglers, boaters and kite surfers. The RSPB manage visitors and direct disturbance to birds and their supporting habitat.	4776, 4774, 4770 5069
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: conservation measures	Maintain the structure, function and supporting processes associated with the feature and its supporting habitat through management or other measures (whether within and/or outside the site boundary as appropriate) and ensure these measures are not being undermined or compromised.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This target has been included because active and ongoing conservation management is often needed to protect, maintain or restore this feature at this site. Other measures may also be required, and in some cases, these measures may apply to areas outside of the designated site boundary in order to achieve this target. Further details about the necessary conservation measures for this site can be provided by Natural England. This information will typically be found within, where applicable, supporting documents such as Natura 2000 Site Improvement Plan, Site Management Strategies or Plans, the Views about Management Statement for the underpinning SSSI and/or management agreements.		Further information can be found within the Natura 2000 site improvement plan for Pagham Harbour, and the Pagham Harbour RSPB site management plan. For more information on management of the SSSI that underpin the SPA please contact you local Natural England adviser.	4770, 4774
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: connectivity with supporting habitats	Maintain safe passage of birds moving between roosting and feeding areas		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target has been included because the ability of the feature to safely and successfully move to and from feeding and roosting areas is critical to adult fitness and survival. This target will apply within the site boundary and where birds regularly move to and from off-site habitat where this is relevant.	[33]		4774, 834
Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: air quality	Maintain concentrations and deposition of air pollutants at below the site-relevant Critical Load or Level values given for this feature of the site on the Air Pollution Information System (www.apis.ac.uk). Nitrogen deposition: Pioneer, low-mid, mid-upper saltmarshes: Critical Loads (kg N/ha/yr): 20-30 Ammonia : Littoral sediment: Critical Level (µg NH3/m3 annual mean): 3 (2-4 µg NH3 m-3) (set for Higher Plants)		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target has been included because the structure and function of habitats which support this SPA feature may be sensitive to changes in air quality. Exceeding critical values for air pollutants may result in changes to the chemical status of its habitat substrate, accelerating or damaging plant growth, altering vegetation structure and composition and thereby affecting the quality and availability of feeding or roosting habitats. Critical Loads and Levels are thresholds below which such harmful effects on sensitive UK habitats will not occur to a noteworthy level, according to current levels of scientific understanding. There are critical levels for ammonia (NH3), oxides of nitrogen (NOx) and sulphur dioxide (SO2), and critical loads for nutrient nitrogen deposition and acid deposition. It is recognised that achieving this target may be subject to the development, availability and effectiveness of abatement technology and measures to tackle diffuse air pollution, within realistic timescales. There are currently no critical loads or levels for other pollutants such as Halogens, Heavy Metals, POPs, VOCs or Dusts. These should be considered as appropriate on a case-by-case basis. Ground level ozone is regionally important as a toxic air pollutant but flux-based critical levels for the protection of semi-natural habitats are still under development.		Dark-bellied brent goose are sensitive to changes in saltmarsh habitat as a result of nitrogen deposition. Current level of nitrogen deposition levels at this site are lower than the critical load for this habitat. Dark bellied-brent goose are also sensitive to impacts on littoral sediment (broad scale habitat) caused by ammonia. The current levels of ammonia are unknown.	

Pagham Harbour	SPA	Dark-bellied Brent goose - (Non-breeding)	Supporting habitat: food availability within grassland (improved)	Maintain a high cover/abundance of preferred food plants (e.g. Agrostis stolonifera, Lolium perenne, Trifolium repens).		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target is included because the availability of an abundant food supply is critically important for adult fitness and survival and the overall sustainability of the population. As a result, inappropriate management and direct or indirect impacts which may affect the distribution, abundance and availability of prey may adversely affect the population.	[1233;94;104]	*Lolium perenne* and *Agrostis stolonifera* has been recorded as present in Ferry Fields, Halsey's farm. *Lolium perenne* - has also been recorded as present at Glebe meadow and the Sam.	4774
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: water depth		Maintain the availability of water at optimal depths, typically 1-3 cm deep.	The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This feature is known to require extensive areas of water in which to feed. Birds are visual predators, with some having the ability to dive or to feed from the surface. As they will rely on detecting their prey within the water to hunt, the depth of water at critical times of year may be paramount for successful feeding and therefore their fitness and survival. Deep water surrounding nesting sites may also be important to deterring predators.	[103;102]		4774
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: water quality: nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities and hence adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. The aim is to seek no further deterioration or improve water quality. However, there is significant natural variability that should be considered. Targets will be specific to the type of supporting habitat in the site. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.		The risk of eutrophication across the site has been assessed as low using the Environment Agency's Weight of Evidence approach. This takes into account assessments of the Water Framework Directive opportunistic macroalgae and phytoplankton quality elements using the respective assessment tools. Adverse effects to integrity should be avoided. Therefore opportunistic macroalgal levels should be maintained so there is no adverse effect to the feature through limited algal cover (<15%) and low biomass (< 500 g m2) of macroalgal blooms in the available intertidal habitat, with area of available intertidal habitat affected by opportunistic macroalgae less than 15 %. There should also be limited (<5%) entrainment of algae in the underlying sediment (all accounting for seasonal variations and fluctuations in growth). Phytoplankton levels should be maintained above a WFD assessment tool score of 0.6, where there is only a minor (a) decline in species richness, and (b) disturbance to the diatom-dinoflagellate succession in the spring bloom compared to reference condition	
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: water quality: dissolved oxygen	Maintain the dissolved oxygen (DO) concentration to levels equating to High Ecological Status avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Dissolved Oxygen (DO) levels affect the condition and health of supporting habitats. Excessive nutrients and/or high turbidity can lead to a drop in DO, especially in warmer months. Low DO can have sub-lethal and lethal impacts on fish and infauna and epifauna communities [1034] and hence can adversely affect the availbility and suitability of bird breeding, rearing, feeding and roosting habitats. However, there is a significant amount of natural variation that should be considered. Targets will be specific to the types of supporting habitat in the site. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.		Measurements of oxygen in Pagham Lagoon and Pagham Harbour for the years 2008 to 2013 record dissolved oxygen concentration of between 2.14mg/l (August reading and 15.4mg/l (April reading). Percentage of dissolved oxygen saturation varies throughout the year with a percentage saturation range of between 23% and 150% with no discernable seasonal pattern	4490
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: water quality: contaminants	Restrict aqueous contaminants to levels equating to [Good/High] Status, avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Contaminants may have a range of biological effects on different species within the supporting habitat, depending on the nature of the contaminant. This in turn can adversely affect the availability of bird breeding, rearing, feeding and roosting habitats. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.			
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: water quality: turbidity	Maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) across the habitat.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution or other matter from land sources. Turbidity levels can rise and fall rapidly as a result of biological (eg plankton blooms), physical (eg storm events) or human (eg development) factors. Prolonged changes in turbidity may influence the amount of light reaching supporting habitats, affecting the primary production and nutrient levels of the habitat's associated communities. Changes in turbidity may also have a range of biological effects on different species within the habitat, eg affecting their abilities to feed or breathe. A prolonged increase in turbidity is indicative of an increase in suspended particulates. This has a number of implications for the aquatic/marine environment, such as affecting fish health, clogging the filtering organs of suspension feeding animals and affecting sedimentation rates. This in turn can adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.			4774
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: vegetation characteristics for feeding	Maintain the extent and distribution of predominantly short (<10 cm) grassland swards or arable fields in areas used for feeding		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		The height, cover, variation and composition of vegetation are often important characteristics of habitats supporting this feature which enables successful concealment/roosting/foraging/feeding and/or displaying. Many bird species will have specific requirements that conservation measures will aim to maintain, for others such requirements will be less clear. Activities that may directly or indirectly affect the vegetation of supporting habitats and modify these characteristics may adversely affect the feature.			4774
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: vegetation characteristics for roosting	Maintain a vegetation structure of key roost sites dominated by bare ground or a short sparsely-vegetated sward.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		The height, cover, variation and composition of vegetation are often important characteristics of habitats supporting this feature which enables successful concealment/roosting/foraging/feeding and/or displaying. Many bird species will have specific requirements that conservation measures will aim to maintain, for others such requirements will be less clear. Activities that may directly or indirectly affect the vegetation of supporting habitats and modify these characteristics may adversely affect the feature.			4774
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: landscape	Maintain open and unobstructed terrain around nesting, roosting and feeding sites.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This feature is known to favour large areas of open terrain, largely free of obstructions, in and around its roosting and feeding areas. Often there is a need to maintain an unobstructed line of sight within feeding or roosting habitat to detect approaching predators, or to ensure visibility of displaying behaviour. An open landscape may also be required to facilitate movement of birds between the SPA and any off-site supporting habitat.			4774, 4490

Pagham Harbour	SPA	Ruff - (Non-breeding)	Non-breeding population: abundance		Restore the size of the non-breeding population to a level which is above 160 individuals, whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.		There is evidence from survey or monitoring that shows the feature to be in declining condition and/or currently impacted by anthropogenic activities	This will sustain the site's population and contribute to a viable local, national and bio-geographic population. Due to the mobility of this feature and the dynamic nature of population change, the target-value given for the population size of this feature is considered to be the minimum standard for conservation/restoration measures to achieve. This minimum-value may be revised where there is evidence to show that a population's size has significantly changed as a result of natural factors or management measures and has been stable at or above a new level over a considerable period (generally at least 10 years). The values given here may also be updated in future to reflect any strategic objectives which may be set at a national level for this feature. Given the likely fluctuations in numbers over time, any impact-assessments should focus on the current size of the site's population, as derived from the latest known or estimated level established using the best available data. This advice accords with the obligation to avoid deterioration of the site or significant disturbance of the species for which the site is classified, and seeks to avoid plans or projects that may affect the site giving rise to the risk of deterioration. Similarly, where there is evidence to show that a feature has historically been more abundant than the stated minimum target and its current level, the ongoing capacity of the site to accommodate the feature at such higher levels in future should also be taken into account. Maintaining or restoring bird abundance depends on the suitability of the site. However, factors affecting suitability can also determine other demographic rates of birds using the site including survival (dependent on factors such as body condition which influences the ability to breed or make foraging and / or migration movements) and breeding productivity. Adverse anthropogenic impacts on either of these rates may precede changes in population abundance (e.g. by changing proportions of birds of different ages) but eventually may negatively affect abundance. These rates can be measured / estimated to inform judgements of likely impacts on abundance targets. Unless otherwise stated, the population size will be that measured using standard methods such as peak mean counts or breeding surveys. This value is also provided recognising there will be inherent variability as a result of natural fluctuations and margins of error during data collection. Whilst we will endeavour to keep these values as up to date as possible, local Natural England staff can advise whether the figures stated are the best available.		For the classification in 1988, the SPA non-breeding population was given as 160 individuals according to the five year peak mean of 1980/1981 to 1985/1986, (English Nature,1988) which represent 10% of the British wintering popultion. Since classification, the SPA 's population declined to 10 individuals (1995-1999 five year peak mean) and then only to one individual on average between 2010-2014. The trends on the site appear to be tracking that of the region although not the overall British trend.	4771, 947, 4179
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: landform	Maintain shallow slope gradients to the length/perimeter of ditches, drains, pools and scrapes.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This attribute ensures that important habitats used by the feature are not impacted, regardless of whether the bird is present at that time. The physical topography and landform of a site will strongly influence the quality and extent of supporting habitats used by this feature for feeding and/or roosting as appropriate. This will also influence the interactions with underlying supporting processes on which the supporting habitat may rely. Any changes or modifications to site topography may adversely affect the ability of the supporting habitats to support and sustain this feature.	[86;93;16;266]		
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: air quality	Maintain concentrations and deposition of air pollutants at below the site-relevant Critical Load or Level values given for this feature of the site on the Air Pollution Information System (www.apis.ac.uk).		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target has been included because the structure and function of habitats which support this SPA feature may be sensitive to changes in air quality. Exceeding critical values for air pollutants may result in changes to the chemical status of its habitat substrate, accelerating or damaging plant growth, altering vegetation structure and composition and thereby affecting the quality and availability of feeding or roosting habitats. Critical Loads and Levels are thresholds below which such harmful effects on sensitive UK habitats will not occur to a noteworthy level, according to current levels of scientific understanding. There are critical levels for ammonia (NH3), oxides of nitrogen (NOx) and sulphur dioxide (SO2), and critical loads for nutrient nitrogen deposition and acid deposition. It is recognised that achieving this target may be subject to the development, availability and effectiveness of abatement technology and measures to tackle diffuse air pollution, within realistic timescales. There are currently no critical loads or levels for other pollutants such as Halogens, Heavy Metals, POPs, VOCs or Dusts. These should be considered as appropriate on a case-by-case basis. Ground level ozone is regionally important as a toxic air pollutant but flux-based critical levels for the protection of semi-natural habitats are still under development.			
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: disturbance caused by human activity	Restrict the frequency, duration and / or intensity of disturbance affecting roosting, nesting, foraging, feeding, moulting and/or loafing birds so that they are not significantly disturbed		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		The nature, scale, timing and duration of some human activities can result in the disturbance of birds at a level that may substantially affect their behaviour, and consequently affect the long-term viability of the population. Such disturbing effects can for example result in changes to feeding or roosting behaviour, increases in energy expenditure due to increased flight and desertion of supporting habitat (both within or outside the designated site boundary where appropriate). This may undermine successful feeding and/or roosting, and/or may reduce the availability of suitable habitat as birds are displaced and their distribution within the site contracts. Disturbance associated with human activity may take a variety of forms including noise, light, sound, vibration, trampling, presence of people, animals and structures.		Pagham harbour being a small area means that the birds using this site are more susceptible to disturbance. The public footpath and open access areas are regularly used by walkers, bird watchers, dog walkers, anglers, boaters and kite surfers. The RSPB manage visitors and direct disturbance to birds and their supporting habitat.	4776, 4774, 4770 5069
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: extent and distribution of supporting non-breeding habitat		Maintain the extent and distribution of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of the non-breeding/wintering period (moulting, roosting, loafing, feeding) at: Annual vegetation of driftline/shingle: 44.8ha Coastal Lagoon: 13.21ha Freshwater and coastal grazing marsh: 81.71 ha Intertidal mud: 116.76 ha Intertidal sand and muddy sand 1.83ha Saltmarsh: 98.6 ha The figures for extents are based on best available evidence, and due to a shifting	There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This target may apply to supporting habitat which also lies outside the site boundary.		Wintering ruff feed primarily on invertebrates in wet/damp grassland in winter. Currently Pagham harbour contains 98.6 ha of saltmarsh and a further 81.71 ha of freshwater and coastal grazing marsh. Some of these habitats extend beyond the European marine site boundary. Ruff will also occasionally feed in other habitats, including areas of intertidal mud and sand (currently covering 118.59 ha).	3002, 4844, 4770, 4490, 5045, 5046, 2975
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: food availability within supporting habitat	Maintain availability of key prey species (e.g. dipteran flies, beetles, earthworms) at preferred prey sizes.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target is included because the availability of an abundant food supply is critically important for adult fitness and survival and the overall sustainability of the population. As a result, inappropriate management and direct or indirect impacts which may affect the distribution, abundance and availability of prey may adversely affect the population.	[110;91]		
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: food availability within the intertidal	Maintain the availability of key prey species (e.g. Caddis flies, crustaceans, molluscs and worms) of preferred prey sizes.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target is included because the availability of an abundant food supply is critically important for adult fitness and survival and the overall sustainability of the population. As a result, inappropriate management and direct or indirect impacts which may affect the distribution, abundance and availability of prey may adversely affect the population.	[94]		

Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: conservation measures	Maintain the structure, function and supporting processes associated with the feature and its supporting habitat through management or other measures (whether within and/or outside the site boundary as appropriate) and ensure these measures are not being undermined or compromised.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This target has been included because active and ongoing conservation management is often needed to protect, maintain or restore this feature at this site. Other measures may also be required, and in some cases, these measures may apply to areas outside of the designated site boundary in order to achieve this target. Further details about the necessary conservation measures for this site can be provided by Natural England. This information will typically be found within, where applicable, supporting documents such as Natura 2000 Site Improvement Plan, Site Management Strategies or Plans, the Views about Management Statement for the underpinning SSSI and/or management agreements.		Further information can be found within the Natura 2000 site improvement plan for Pagham Harbour, and the Pagham Harbour RSPB site management plan. For more information on management of the SSSI that underpin the SPA please contact you local Natural England adviser.	4770, 4774
Pagham Harbour	SPA	Ruff - (Non-breeding)	Supporting habitat: connectivity with supporting habitats	Maintain safe passage of birds moving between roosting and feeding areas.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target has been included because the ability of the feature to safely and successfully move to and from feeding and roosting areas is critical to adult fitness and survival. This target will apply within the site boundary and where birds regularly move to and from off-site habitat where this is relevant.			4774
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: water quality: contaminants	Restrict aqueous contaminants to levels equating to [Good/High] Status, avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Contaminants may have a range of biological effects on different species within the supporting habitat, depending on the nature of the contaminant. This in turn can adversely affect the availability of bird breeding, rearing, feeding and roosting habitats. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.			
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: disturbance caused by human activity	Restrict the frequency, duration and / or intensity of disturbance affecting roosting, nesting, foraging, feeding, moulting and/or loafing birds so that they are not significantly disturbed		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		The nature, scale, timing and duration of some human activities can result in the disturbance of birds at a level that may substantially affect their behaviour, and consequently affect the long-term viability of the population. Such disturbing effects can for example result in changes to feeding or roosting behaviour, increases in energy expenditure due to increased flight, abandonment of nest sites and desertion of supporting habitat (both within or outside the designated site boundary where appropriate). This may undermine successful nesting, rearing, feeding and/or roosting, and/or may reduce the availability of suitable habitat as birds are displaced and their distribution within the site contracts. Disturbance associated with human activity may take a variety of forms including noise, light, sound, vibration, trampling, presence of people, animals and structures.		Pagham harbour being a small area means that the birds using this site are more susceptible to disturbance. This site has open access over the shingle beach area, which includes along with other species, common tern nesting sites. The public footpath and open access areas are regularly used by walkers, bird watchers, dog walkers, anglers, boaters and kite surfers. The terns are fenced off during breeding season but many are disturbed by dogs being walked of the leads. The RSPB manage visitors and direct disturbance to birds and their supporting habitat.	4776, 4774, 4770, 5069
Pagham Harbour	SPA	Common tern - (Breeding)	Breeding population: abundance	Maintain the size of the breeding population at a level to be agreed* whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This will sustain the site's population and contribute to a viable local, national and bio-geographic population. Due to the mobility of this feature and the dynamic nature of population change, the target-value given for the population size of this feature is considered to be the minimum standard for conservation/restoration measures to achieve. This minimum-value may be revised where there is evidence to show that a population's size has significantly changed as a result of natural factors or management measures and has been stable at or above a new level over a considerable period (generally at least 10 years). The values given here may also be updated in future to reflect any strategic objectives which may be set at a national level for this feature. Given the likely fluctuations in numbers over time, any impact-assessments should focus on the current size of the site's population, as derived from the latest known or estimated level established using the best available data. This advice accords with the obligation to avoid deterioration of the site or significant disturbance of the species for which the site is classified, and seeks to avoid plans or projects that may affect the site giving rise to the risk of deterioration. Similarly, where there is evidence to show that a feature has historically been more abundant than the stated minimum target and its current level, the ongoing capacity of the site to accommodate the feature at such higher levels in future should also be taken into account. Maintaining or restoring bird abundance depends on the suitability of the site. However, factors affecting suitability can also determine other demographic rates of birds using the site including survival (dependent on factors such as body condition which influences the ability to breed or make foraging and / or migration movements) and breeding productivity. Adverse anthropogenic impacts on either of these rates may precede changes in population abundance (e.g. by changing proportions of birds of different ages) but eventually may negatively affect abundance. These rates can be measured / estimated to inform judgements of likely impacts on abundance targets. Unless otherwise stated, the population size will be that measured using standard methods such as peak mean counts or breeding surveys. This value is also provided recognising there will be inherent variability as a result of natural fluctuations and margins of error during data collection. Whilst we will endeavour to keep these values as up to date as possible, local Natural England staff can advise whether the figures stated are the best available.		*In the absence of an abundance value from the SPA citation. For information, the JNCC standard data form states there were 0 pairs of breeding common terns. The latest 5-year mean peak count is 11 breeding pairs (2010-2014), which represents 0.11% of the GB breeding population. Natural England will consider this value as one option to inform the numerical target in due course. Please contact your local NE adviser for further information. When classified in 1988 the size of the breeding colony fell under the typical SPA qualification thresholds, but the long history of natural occupation situated within the core rang of common terns on the South Coast allowed the addition of common terns as a feature of the SPA in order to protect the 'most suitable territories'.	4772, 4773
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat (function/supporting process): water area	Maintain the number of waterbodies of optimal size.			This site is managed by the RSPB which ensure the supporting habitat is maintained	This feature depends on the presence and continuity of open water habitat; often requiring water bodies of a particular size to in order to successfully nest, rear their young, feed and/or roost. Changes in water area, and associated marginal habitat, can adversely affect the suitability of supporting open water habitat within which nests may be situated.		Pagham Harbour is a tidal inlet with an area of approximately 2.8km^2 at mean high water tides.The inlet is fronted by a dynamic shingle beach complex which provides shelter from open-coast wave action. Pagham Harbour is surrounded by lagoons and open water.	4770, 5067
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: air quality	Maintain concentrations and deposition of air pollutants at below the site-relevant Critical Load or Level values given for this feature of the site on the Air Pollution Information System (www.apis.ac.uk). Critical level (Ammonia : Supralittoral sediment and open water: Critical Level (µg NH3/m3 annual mean): 3 (2-4 µg NH3 m-3) (set for Higher Plants). NOx: Supralittoral sediment and open water : Critical Level (µg NOx/m3 annual mean): 30 (set for all vegetation). Critical Level (µg NOx/m3 24-hour mean): 75 (set for all vegetation)		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target has been included because the structure and function of habitats which support this SPA feature may be sensitive to changes in air quality. Exceeding critical values for air pollutants may result in changes to the chemical status of its habitat substrate, accelerating or damaging plant growth, altering vegetation structure and composition and thereby affecting the quality and availability of nesting, feeding or roosting habitats. Critical Loads and Levels are thresholds below which such harmful effects on sensitive UK habitats will not occur to a noteworthy level, according to current levels of scientific understanding. There are critical levels for ammonia (NH3), oxides of nitrogen (NOx) and sulphur dioxide (SO2), and critical loads for nutrient nitrogen deposition and acid deposition. It is recognised that achieving this target may be subject to the development, availability and effectiveness of abatement technology and measures to tackle diffuse air pollution, within realistic timescales. There are currently no critical loads or levels for other pollutants such as Halogens, Heavy Metals, POPs, VOCs or Dusts. These should be considered as appropriate on a case-by-case basis. Ground level ozone is regionally important as a toxic air pollutant but flux-based critical levels for the protection of semi-natural habitats are still under development.		Breeding common terns are sensitive to changes in the suppralittoral sediment (broadscale habitat) and open water caused by ammonia and NOx. The current levels are unknown	

Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: connectivity with supporting habitats	Maintain safe passage of birds moving between nesting and feeding areas, generally within 15 km of breeding colonies.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target has been included because the ability of the feature to safely and successfully move to and from nesting, feeding and roosting areas is critical to their breeding success and to the adult fitness and survival. This target will apply within the site boundary and where birds regularly move to and from off-site habitat where this is relevant.	[26;60;27;28]		4774
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: conservation measures	Maintain the structure, function and supporting processes associated with the feature and its supporting habitat through management or other measures (whether within and/or outside the site boundary as appropriate) and ensure these measures are not being undermined or compromised.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This target has been included because active and ongoing conservation management is often needed to protect, maintain or restore this feature at this site. Other measures may also be required, and in some cases, these measures may apply to areas outside of the designated site boundary in order to achieve this target. Further details about the necessary conservation measures for this site can be provided by Natural England. This information will typically be found within, where applicable, supporting documents such as Natura 2000 Site Improvement Plan, Site Management Strategies or Plans, the Views about Management Statement for the underpinning SSSI and/or management agreements.		Further information can be found within the Natura 2000 site improvement plan for Pagham Harbour, and the Pagham Harbour RSPB site management plan. For more information on management of the SSSI that underpin the SPA please contact you local Natural England adviser.	4770, 4774
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: extent and distribution of supporting habitat for the breeding season		Maintain the extent, distribution and availability of suitable breeding habitat which supports the feature for all necessary stages of its breeding cycle (courtship, nesting, feeding) at: Annual vegetation of driftline/shingle: 44.8ha Coastal Lagoon: 13.21 ha Freshwater and coastal grazing marsh: 81.71 ha Saltmarsh: 98.6 ha Water column: Extent is unknown The figures for extents are based on best available evidence, and due to a shifting baseline may differ from those at time of designation.			To maintain or restore the extent of supporting habitats and their range in order to maintain the population. The information available on the extent and distribution of supporting habitat used by the feature may be approximate depending to the nature, age and accuracy of data collection.		Within Pagham Harbour common terns typically nest on undisturbed areas of bare or lightly vegetated shingle above mean high water. This habitat occurs on both Church Norton Spit and Tern Island and forms part of the habitat defined as annual vegetation of driftlines (ADVL). The extent of Church Norton Spit has increased rapidly and significantly since 2005, however the feature is dynamic and subject to natural change. Coastal processes alongside sea level rise has the potential to change the extent of supporting habitat (erosion and accretion).	2914, 4844, 5045, 5046, 2975, 4770, 4490
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: food availability within supporting habitat	Maintain availability of key prey items (e.g. sandeel, sprat, coarse fish, crustacea, annelids) at preferred prey sizes.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target is included because the availability of an abundant food supply is critically important for successful breeding, adult fitness and survival and the overall sustainability of the population. As a result, inappropriate management and direct or indirect impacts which may affect the distribution, abundance and availability of prey may adversely affect the population.	[100;26]		
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: predation: all habitats	Restrict predation and disturbance caused by native and non-native predators		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This will ensure that breeding productivity (number of chicks per pair) and survival are sustained at rates that maintain or restore the abundance of the feature. Impacts to breeding productivity can result directly from predation of eggs, chicks, juveniles and adults, but also from significant disturbance. The presence of predators can influence bird behaviours, such as abandonment of nest sites or reduction of effective feeding. Where evidence suggests predator management is required, measures can include their exclusion through fencing,scaring and direct control. Any such measures must consider the legal protection of some predators, as well as the likely effects of such control on other qualifying features.	[4193; 4194]	Foxes are present in Pagham Harbour and are known to predate on the nesting terns. RSPB have erected targeted fencing on tern island and Church Norton spit.	4772, 4773
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: vegetation characteristics for nesting	Maintain the mix or heights of vegetation types within and immediately adjacent to nesting areas .			RSPB will ensure the appropriate management of the vegetation is carried out for successful tern nesting	The height, cover, variation and composition of vegetation are often important characteristics of habitats supporting this feature which enables successful nesting/rearing/concealment/roosting/foraging/feeding and/or displaying. Many bird species will have specific requirements that conservation measures will aim to maintain, for others such requirements will be less clear. Activities that may directly or indirectly affect the vegetation of supporting habitats and modify these characteristics may adversely affect the feature.	[101;45]		
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: water quality: dissolved oxygen	Maintain the dissolved oxygen (DO) concentration to levels equating to High Ecological Status avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Dissolved Oxygen (DO) levels affect the condition and health of supporting habitats. Excessive nutrients and/or high turbidity can lead to a drop in DO, especially in warmer months. Low DO can have sub-lethal and lethal impacts on fish and infauna and epifauna communities [1034] and hence can adversely affect the availbility and suitability of bird breeding, rearing, feeding and roosting habitats. However, there is a significant amount of natural variation that should be considered. Targets will be specific to the types of supporting habitat in the site. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.		Measurements of oxygen in Pagham Lagoon and Pagham Harbour for the years 2008 to 2013 record dissolved oxygen concentration of between 2.14mg/l (August reading and 15.4mg/l (April reading). Percentage of dissolved oxygen saturation varies throughout the year with a percentage saturation range of between 23% and 150% with no discernable seasonal pattern	4490
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: water quality: nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities and hence adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. The aim is to seek no further deterioration or improve water quality. However, there is significant natural variability that should be considered. Targets will be specific to the type of supporting habitat in the site. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.		The risk of eutrophication across the site has been assessed as low using the Environment Agency's Weight of Evidence approach. This takes into account assessments of the Water Framework Directive opportunistic macroalgae and phytoplankton quality elements using the respective assessment tools. Adverse effects to integrity should be avoided. Therefore opportunistic macroalgal levels should be maintained so there is no adverse effect to the feature through limited algal cover (<15%) and low biomass (< 500 g m2) of macroalgal blooms in the available intertidal habitat, with area of available intertidal habitat affected by opportunistic macroalgae less than 15 %. There should also be limited (<5%) entrainment of algae in the underlying sediment (all accounting for seasonal variations and fluctuations in growth). Phytoplankton levels should be maintained above a WFD assessment tool score of 0.6, where there is only a minor (a) decline in species richness, and (b) disturbance to the diatom-dinoflagellate succession in the spring bloom compared to reference condition	

Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: water quality: turbidity	Maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) across the habitat.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution or other matter from land sources. Turbidity levels can rise and fall rapidly as a result of biological (eg plankton blooms), physical (eg storm events) or human (eg development) factors. Prolonged changes in turbidity may influence the amount of light reaching supporting habitats, affecting the primary production and nutrient levels of the habitat's associated communities. Changes in turbidity may also have a range of biological effects on different species within the habitat, eg affecting their abilities to feed or breathe. A prolonged increase in turbidity is indicative of an increase in suspended particulates. This has a number of implications for the aquatic/marine environment, such as affecting fish health, clogging the filtering organs of suspension feeding animals and affecting sedimentation rates. This in turn can adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.			
Pagham Harbour	SPA	Common tern - (Breeding)	Supporting habitat: landform	Maintain the availability of shallow sloping nesting sites located greater than 30 cm above water level, so as to minimise the probability of them being flooded.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		The physical topography and landform of a site will strongly influence the quality and extent of supporting habitats used by this feature for nesting/rearing, feeding and/or roosting as appropriate. This will also influence the interactions with underlying supporting processes on which the supporting habitat may rely. Any changes or modifications to site topography may adversely affect the ability of the supporting habitats to support and sustain this feature.	[107]	Both Church Norton Spit and Tern Island are shallow sloping habitats greater than 30 cm above water level.	
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: connectivity with supporting habitats	Maintain safe passage of birds moving between nesting and feeding areas, generally within 6 km of breeding colonies.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target has been included because the ability of the feature to safely and successfully move to and from nesting, feeding and roosting areas is critical to their breeding success and to the adult fitness and survival. This target will apply within the site boundary and where birds regularly move to and from off-site habitat where this is relevant.	[91;2131;28]		4774
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: air quality	Maintain concentrations and deposition of air pollutants at below the site-relevant Critical Load or Level values given for this feature of the site on the Air Pollution Information System (www.apis.ac.uk). Critical level (Ammonia : Supralittoral sediment and open water: Critical Level (µg NH3/m3 annual mean): 3 (2-4 µg NH3 m-3) (set for Higher Plants). NOx: Supralittoral sediment and open water : Critical Level (µg NOx/m3 annual mean): 30 (set for all vegetation). Critical Level (µg NOx/m3 24-hour mean): 75 (set for all vegetation)		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target has been included because the structure and function of habitats which support this SPA feature may be sensitive to changes in air quality. Exceeding critical values for air pollutants may result in changes to the chemical status of its habitat substrate, accelerating or damaging plant growth, altering vegetation structure and composition and thereby affecting the quality and availability of nesting, feeding or roosting habitats. Critical Loads and Levels are thresholds below which such harmful effects on sensitive UK habitats will not occur to a noteworthy level, according to current levels of scientific understanding. There are critical levels for ammonia (NH3), oxides of nitrogen (NOx) and sulphur dioxide (SO2), and critical loads for nutrient nitrogen deposition and acid deposition. It is recognised that achieving this target may be subject to the development, availability and effectiveness of abatement technology and measures to tackle diffuse air pollution, within realistic timescales. There are currently no critical loads or levels for other pollutants such as Halogens, Heavy Metals, POPs, VOCs or Dusts. These should be considered as appropriate on a case-by-case basis. Ground level ozone is regionally important as a toxic air pollutant but flux-based critical levels for the protection of semi-natural habitats are still under development.		Breeding little terns are sensitive to changes in the supralittoral sediment (broadscale habitat) caused by ammonia and NOx. The current levels are unknown	
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: conservation measures	Maintain the structure, function and supporting processes associated with the feature and its supporting habitat through management or other measures (whether within and/or outside the site boundary as appropriate) and ensure these measures are not being undermined or compromised.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This target has been included because active and ongoing conservation management is often needed to protect, maintain or restore this feature at this site. Other measures may also be required, and in some cases, these measures may apply to areas outside of the designated site boundary in order to achieve this target. Further details about the necessary conservation measures for this site can be provided by Natural England. This information will typically be found within, where applicable, supporting documents such as Natura 2000 Site Improvement Plan, Site Management Strategies or Plans, the Views about Management Statement for the underpinning SSSI and/or management agreements.		Further information can be found within the Natura 2000 site improvement plan for Pagham Harbour, and the Pagham Harbour RSPB site management plan. For more information on management of the SSSI that underpin the SPA please contact you local Natural England adviser.	4770, 4774
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: disturbance caused by human activity	Restrict the frequency, duration and / or intensity of disturbance affecting roosting, nesting, foraging, feeding, moulting and/or loafing birds so that they are not significantly disturbed		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		The nature, scale, timing and duration of some human activities can result in the disturbance of birds at a level that may substantially affect their behaviour, and consequently affect the long-term viability of the population. Such disturbing effects can for example result in changes to feeding or roosting behaviour, increases in energy expenditure due to increased flight, abandonment of nest sites and desertion of supporting habitat (both within or outside the designated site boundary where appropriate). This may undermine successful nesting, rearing, feeding and/or roosting, and/or may reduce the availability of suitable habitat as birds are displaced and their distribution within the site contracts. Disturbance associated with human activity may take a variety of forms including noise, light, sound, vibration, trampling, presence of people, animals and structures.		Pagham harbour being a small area means that the birds using this site are more susceptible to disturbance. This site has open access over the shingle beach area, which includes along with other species, little tern nesting sites. The public footpath and open access areas are regularly used by walkers, bird watchers, dog walkers, anglers, boaters and kite surfers. The terns are fenced off during breeding season but many are disturbed by dogs being walked of the leads. The RSPB manage visitors and direct disturbance to birds and their supporting habitat.	4776, 4774, 4770, 5069

Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: extent and distribution of supporting habitat for the breeding season		Maintain the extent, distribution and availability of suitable breeding habitat which supports the feature for all necessary stages of its breeding cycle (courtship, nesting, feeding) at: Annual vegetation of driftline/shingle: 44.8ha Coastal Lagoon: 13.21 ha Water column: Extent is unknown The figures for extents are based on best available evidence, and due to a shifting baseline may differ from those at time of designation.			To maintain or restore the extent of supporting habitats and their range in order to maintain the population. The information available on the extent and distribution of supporting habitat used by the feature may be approximate depending to the nature, age and accuracy of data collection.		Within Pagham Harbour little terns typically nest on undisturbed areas of shingle with no vegetation. This habitat occurs on Church Norton Spit and forms part of the habitat defined as annual vegetation of driftlines (ADVL). The early stages of vegetated shingle of ADVL naturally have extensive areas of bare shingle caused by accretion of newly deposited material. Little terns prefer to nest on freshly accreted shingle found above the mean high water line at Pagham. The extent of Church Norton Spit has increased rapidly and significantly since 2005, however the feature is dynamic and subject to natural change. Coastal processes alongside sea level rise have the potential to change the extent of supporting habitat (erosion and accretion).	4844, 2975, 4490
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: food availability within coastal and offshore waters	Maintain availability of key prey species (e.g. crustacea, annelids, sandeel, herring, clupeidae) at preferred prey sizes.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This target is included because the availability of an abundant food supply is critically important for successful breeding, adult fitness and survival and the overall sustainability of the population. As a result, inappropriate management and direct or indirect impacts which may affect the distribution, abundance and availability of prey may adversely affect the population.	[100;91;2131]		
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: landform	Maintain the availability of shallow sloping nesting sites, grading to <30cm above water level, so as to minimise the probability of them being flooded.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		The physical topography and landform of a site will strongly influence the quality and extent of supporting habitats used by this feature for nesting/rearing, feeding and/or roosting as appropriate. This will also influence the interactions with underlying supporting processes on which the supporting habitat may rely. Any changes or modifications to site topography may adversely affect the ability of the supporting habitats to support and sustain this feature.	[91]	Both Church Norton Spit and Tern Island are shallow sloping habitats greater than 30 cm above water level.	
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: vegetation characteristics for nesting	Maintain vegetation cover (generally <15%) throughout areas used for nesting, providing sufficient bare ground for the colony as a			RSPB will ensure the appropriate management of the vegetation is carried out for successful tern nesting	The height, cover, variation and composition of vegetation are often important characteristics of habitats supporting this feature which enables successful nesting/rearing/concealment/roosting/foraging/feeding and/or displaying. Many bird species will have specific requirements that conservation measures will aim to maintain, for others such requirements will be less clear. Activities that may directly or indirectly affect the vegetation of supporting habitats and modify these characteristics may adversely affect the feature.	[2522;503;91]		
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: water quality: contaminants	Restrict aqueous contaminants to levels equating to [Good/High] Status, avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Contaminants may have a range of biological effects on different species within the supporting habitat, depending on the nature of the contaminant. This in turn can adversely affect the availability of bird breeding, rearing, feeding and roosting habitats. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.			
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: water quality: dissolved oxygen	Maintain the dissolved oxygen (DO) concentration to levels equating to High Ecological Status avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		Dissolved Oxygen (DO) levels affect the condition and health of supporting habitats. Excessive nutrients and/or high turbidity can lead to a drop in DO, especially in warmer months. Low DO can have sub-lethal and lethal impacts on fish and infauna and epifauna communities [1034] and hence can adversely affect the availbility and suitability of bird breeding, rearing, feeding and roosting habitats. However, there is a significant amount of natural variation that should be considered. Targets will be specific to the types of supporting habitat in the site. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.		Measurements of oxygen in Pagham Lagoon and Pagham Harbour for the years 2008 to 2013 record dissolved oxygen concentration of between 2.14mg/l (August reading and 15.4mg/l (April reading). Percentage of dissolved oxygen saturation varies throughout the year with a percentage saturation range of between 23% and 150% with no discernable seasonal pattern	4490
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: water quality: nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities and hence adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. The aim is to seek no further deterioration or improve water quality. However, there is significant natural variability that should be considered. Targets will be specific to the type of supporting habitat in the site. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.		The risk of eutrophication across the site has been assessed as low using the Environment Agency's Weight of Evidence approach. This takes into account assessments of the Water Framework Directive opportunistic macroalgae and phytoplankton quality elements using the respective assessment tools. Adverse effects to integrity should be avoided. Therefore opportunistic macroalgal levels should be maintained so there is no adverse effect to the feature through limited algal cover (<15%) and low biomass (< 500 g m2) of macroalgal blooms in the available intertidal habitat, with area of available intertidal habitat affected by opportunistic macroalgae less than 15 %. There should also be limited (<5%) entrainment of algae in the underlying sediment (all accounting for seasonal variations and fluctuations in growth). Phytoplankton levels should be maintained above a WFD assessment tool score of 0.6, where there is only a minor (a) decline in species richness, and (b) disturbance to the diatom-dinoflagellate succession in the spring bloom compared to reference condition	
Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: water quality: turbidity	Maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) across the habitat.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		Water turbidity is a result of material suspended in the water, including sediment, plankton, pollution or other matter from land sources. Turbidity levels can rise and fall rapidly as a result of biological (eg plankton blooms), physical (eg storm events) or human (eg development) factors. Prolonged changes in turbidity may influence the amount of light reaching supporting habitats, affecting the primary production and nutrient levels of the habitat's associated communities. Changes in turbidity may also have a range of biological effects on different species within the habitat, eg affecting their abilities to feed or breathe. A prolonged increase in turbidity is indicative of an increase in suspended particulates. This has a number of implications for the aquatic/marine environment, such as affecting fish health, clogging the filtering organs of suspension feeding animals and affecting sedimentation rates. This in turn can adversely affect the availability and suitability of bird breeding, rearing, feeding and roosting habitats. Typically, meeting the environmental standards set out by the Water Framework Directive (WFD 2000/60/EC) will also be sufficient to support the SPA Conservation Objectives but in some cases more stringent standards may be needed to support the SPA feature. Further site-specific investigations may be required to establish appropriate standards for the SPA.			4772

Pagham Harbour	SPA	Little tern - (Breeding)	Supporting habitat: predation: all habitats	Restrict predation and disturbance caused by native and non-native predators.		The target has been set using expert judgement based on knowledge of the sensitivity of the feature to activities that are occurring / have occurred on the site.		This will ensure that breeding productivity (number of chicks per pair) and survival are sustained at rates that maintain or restore the abundance of the feature. Impacts to breeding productivity can result directly from predation of eggs, chicks, juveniles and adults, but also from significant disturbance. The presence of predators can influence bird behaviours, such as abandonment of nest sites or reduction of effective feeding. Where evidence suggests predator management is required, measures can include their exclusion through fencing,scaring and direct control. Any such measures must consider the legal protection of some predators, as well as the likely effects of such control on other qualifying features.	[4193; 4194]	Foxes are present in Pagham Harbour and are known to predate on the nesting terns. RSPB have erected targeted fencing on tern island and Church Norton spit.	4772, 4773
Pagham Harbour	SPA	Little tern - (Breeding)	Breeding population: abundance	Maintain the size of the breeding population at a level to be agreed* whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.		There is evidence from survey or monitoring that shows the feature to be in a good condition and/or currently un-impacted by anthropogenic activities.		This will sustain the site's population and contribute to a viable local, national and bio-geographic population. Due to the mobility of this feature and the dynamic nature of population change, the target-value given for the population size of this feature is considered to be the minimum standard for conservation/restoration measures to achieve. This minimum-value may be revised where there is evidence to show that a population's size has significantly changed as a result of natural factors or management measures and has been stable at or above a new level over a considerable period (generally at least 10 years). The values given here may also be updated in future to reflect any strategic objectives which may be set at a national level for this feature. Given the likely fluctuations in numbers over time, any impact-assessments should focus on the current size of the site's population, as derived from the latest known or estimated level established using the best available data. This advice accords with the obligation to avoid deterioration of the site or significant disturbance of the species for which the site is classified, and seeks to avoid plans or projects that may affect the site giving rise to the risk of deterioration. Similarly, where there is evidence to show that a feature has historically been more abundant than the stated minimum target and its current level, the ongoing capacity of the site to accommodate the feature at such higher levels in future should also be taken into account. Maintaining or restoring bird abundance depends on the suitability of the site. However, factors affecting suitability can also determine other demographic rates of birds using the site including survival (dependent on factors such as body condition which influences the ability to breed or make foraging and / or migration movements) and breeding productivity. Adverse anthropogenic impacts on either of these rates may precede changes in population abundance (e.g. by changing proportions of birds of different ages) but eventually may negatively affect abundance. These rates can be measured / estimated to inform judgements of likely impacts on abundance targets. Unless otherwise stated, the population size will be that measured using standard methods such as peak mean counts or breeding surveys. This value is also provided recognising there will be inherent variability as a result of natural fluctuations and margins of error during data collection. Whilst we will endeavour to keep these values as up to date as possible, local Natural England staff can advise whether the figures stated are the best available.		*In the absence of an abundance value from the SPA citation. For information, the JNCC standard data form states there were 7 pairs of breeding little terns. The latest 5-year mean peak count is 12 breeding pairs (2010-2014), which represents 0.63% of the GB breeding population. Natural England will consider these values as two options to inform the numerical target in due course. Please contact your local NE adviser for further information. When classified in 1988 the size of the breeding colony fell under the typical SPA qualification thresholds (thresholds introduced in 1999), but the long history of natural occupation situated within the core range of little terns on the South Coast supported the addition of little terns as a feature of the SPA in order to protect the 'most suitable territories'.	4772, 4773, 5068

NATURAL ENGLAND

Geomorphological Advice in respect of ABPmer's proposal for the breaching of Pagham Spit, Sussex

December 2015

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ARUN DISTRICT COUNCIL P/97/15/PL

Natural England Advice Request

i. This report geomorphologically assesses the proposal by ABPmer for establishing a breach across Pagham Harbour Spit (originally Church Norton spit), which would act as the new 'principal' tidal inlet/outlet of Pagham Harbour, and thereby alleviate the contemporary coastal erosion activity down-drift of the current exit to Pagham Harbour (along Pagham Frontage).

ii. Natural England requests specific advice on "Understanding the implications of a man-made breach of the Church Norton spit on coastal processes, in order to determine the impacts and risks to the natural environment."

iii. Understanding the implications of this proposal will enable Natural England to provide advice on the anticipated planning application to carry out the breaching proposal. In particular, impacts on the coastal geomorphology SSSI, and impacts on, and risks to SSSI and SPA habitats need to be assessed. This includes: i) breeding Little Terns on the Church Norton spit; and ii) the potential risk of closure of the harbour to tidal influence with resulting impacts on SPA inner harbour intertidal habitats for overwintering birds.

iv. This geomorphological assessment is based on the following reports:

a. ABPmer Sept 2015a. Managed Breach of Shingle Spit: Environmental Statement. V1: Report, Rept R.2446, 298pp.

b. ABPmer Sept 2015b. Managed Breach of Shingle Spit: Environmental Statement. V2: Appendices, Rept R.2446, 254pp.

v. Natural England needs to understand whether the coastal process and coastal evolution aspects of the ABPmer proposal, represents a credible analysis of the consequences of breaching the spit.

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Executive Summary

1. It is assumed that Natural England staff are already familiar with the overall structural context of the Pagham site, as well as the background to ABPmer's proposal.

2. ABPmer has provided a detailed, and comprehensive Environment Statement concerning the proposal for artificially breaching Church Norton Spit. Such a breach is proposed as a means of sustainably responding to the continuing problem present to coastal properties along the western end of Pagham Frontage, by the contemporary shifting tidally dominant inlet/outlet to Pagham Harbour.

3. The recent changes to Church Norton spit should be regarded by Natural England as being exceptional for a gravel-dominated coastal spit in England and Wales (if not in the UK), and thereby nationally important to scientific investigation for following natural evolution of this feature. The extension of the spit and its formative interaction with the tidal inlet/outlet (Ti/o) offers scientific information of considerable value. All other gravel coastal systems in England and Wales tend to be in a declining sediment supply, best characterised by their swash-alignment status, whereas this site presents an unusual contemporary drift-aligned system, that with the high gravel component means that the potential for continuing spit extension is high. This is in contrast to spit breaching, which is a more common response with sand-based spit /tidal inlet systems

4. There has been considerable re-analysis by ABPmer, in the Environmental Statement, of the historical and geomorphological basis to the evolving tidal entrance and the related flanking spit and ebb-delta system.

5. There is a salient structural difference between gravel-dominated and sand-dominated spits in terms to which wave-lain processes can build up beach crest heights relative to MHWS. Gravel spits have a higher absolute crest height compared to sand spits (excluding wind blown effects). This means that extreme elevations achieved by tidally locked storm-surge water have to be significantly greater for gravel breaching than for sand spit breaching. This explains why sand spits are more likely to breach than gravel spits.

6. The development of a breach and the consequent reworking of the distal end of Pagham spit is justified by ABPmer on the basis that longshore sediment transport of gravel to sustain Pagham Frontage will be reinstated as a 'normal' and 'natural' process. This is a perspective that needs to be challenged by Natural England, as gravel-dominated spit breaching is not a 'normal' process, where the spit is in a drift-aligned status. Likewise, continuous longshore sediment supply to maintain Pagham Frontage is not a normal process. Pagham beach was the result of delta reworking that provided a glut of supply that once depleted, forced the longshore transport system to cannibalise and thereby longshore transport become more episodic and highly variable. Such hiatuses in longshore sediment supply are more the norm for Pagham – hence the observed net retreat of the shoreline, rather than the non-normal observation of steady sediment supply as suggested by the proposal.

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7. The dimensions and stability of the proposed breach have to be questioned as 'uncertain'. The model and empirical justification of breaching can only derive a 1st-order approximation of potential change. If breaching is undertaken, then the likelihood of channel coherence and spatial stability are also questionable. Given the post-breaching changes of the two sites (Porlock and Medmerry) used as breaching justification, then the stability of the upper beach architecture proposed for Pagham needs to be re-examined. Empirical evidence from these 'exemplar' breach sites indicates a high potential of major changes to channel flanks, and channel stability.

8. The breaching proposal means major alteration to the existing distal spit, which is central to the roosting and nesting areas of Little Terns. This is the exact area that in the last five years has proven to be the central area for Little Tern breeding activity at Pagham. Given the success of this site (in national terms) for increasing Tern numbers, the 'moderate' change assessment levelled on this change is somewhat an understatement of the risks involved.

9. The proposal indicates that Adaptive Management is being introduced as working towards a sustainable solution to the issue of shoreline erosion at Pagham Frontage. The proposed breach is not an adaptive solution that leads to a long-term sustainable outcome and should not be used as a justification to implement the breaching proposal. What is being proposed is only a 'Band-Aid' to the long-term challenges to be faced by Pagham Frontage. This proposal's outcome, if positive, will only further support a Hold-the-Line approach to the continuing erosion issues presented at Pagham Frontage. The wider issue of understanding coastal behaviour at Pagham Frontage should be addressed holistically, rather than in the piecemeal way advocated by this proposal.

10. The three remaining groynes near the contemporary exit to Pagham tidal inlet/outlet are working against easterly movement of longshore sediment towards the eastern Pagham Frontage. Regardless of whether the breaching proposal is implemented, the phased removal of these groynes is advocated on the basis that any longshore sediment transport will then be unimpeded in moving onto Pagham Frontage.

Geomorphological Assessment

1. This is a desktop review of reports presented by ABPmer related to the proposed breaching of Pagham Harbour spit (sometimes referred to as Church Norton spit given the proximal connection of the new spit near to Church Norton). The breach is proposed to alleviate the on-going west Pagham Frontage coastal erosion, linked to the mouth of the contemporary tidal inlet/outlet (Ti/o) for Pagham Harbour.

2. Please note that ABPmer record Pagham groynes 4-1 in an eastwards succession, whereas in previous reports to Natural England (Orford, 2013; 2014) the groynes have been listed as 1-4 in an eastwards direction.

3. Understanding the dynamics of Ti/o and spit evolution at Pagham has been at the core of a range of investigations by agencies, academia and consultants over several decades. Such work will not be reviewed here given ABPmer's Environmental Statement (ABPmer, 2015a & b) and its synthesis of this material. The recent rapid extension of the gravel-based Pagham spit has been commented upon elsewhere (Orford, 2014), and is currently regarded by Natural England as exemplifying a set of coastal processes and responses which in time and space offer a rare example of detailed empirical consideration of contemporary gravel-dominated spit dynamics and associated Ti/o evolution. It is rare to find an active spit in which sediment supply allows a drift-aligned development in the spit structure, as in most other cases (e.g. Blakeney and Orfordness) the contemporary longshore supply is greatly reduced (often by coastal defences sealing off sediment sources), thereby cannibalising the spit into a dominant swash-alignment structure. What is being exhibited at Pagham is important within the coastal geomorphology SSSI series, as it represents a rare (and arguably unique) case of contemporary spit extension from a marine sourced gravel supply, with associated changing Ti/o position and associated ebb-delta extension.

4. ABPmer works with a series of assumptions about the proposal, with which I have some reservations. These assumptions are as follows:

    i. The report identifies the justification of breach cutting as being based upon actions being both 'normal' and 'natural' processes of coastal change (ABPmer 2015a: p.39). Breaching the spit will lead to suggested outcomes along the Pagham coast by which contemporary erosion of Pagham Frontage will be stopped by new deposition, an outcome which is regarded as sustainable and beneficial for human occupancy of the Pagham Frontage, and therefore is used as a justification for the breach.

    ii. The report indicates that the 'normal' coastal process is one of constant longshore supply of sediment, which is not affected by the presence of a tidal discharge system, such that any restructuring of the supply is for the good of the system, thereby restoring 'normal' longshore sediment distribution and hence supporting people at the shoreline. I see this perspective as an engineering consultancy axiom – interventionist action is always viewed as good for people, though not necessarily good for nature. Natural England could argue that historically, the 'normal'

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action at this site has been dominated by periods of sediment interruptions as well as sediment reworking, and that Pagham Frontage is itself a major remnant of such a Victorian reworking phase. Variable supply is the natural norm for this system, as contested by the human intervention over historical time. Consistent sediment supply is not the 'normal' situation along this coast

iii. Although there is an understanding of the possible latest sources of sediment supply to the system (i.e. Kirk Arrows and the Inner Owers), that account for the recent growth of Pagham Spit, there is no consideration of why these sources should have been so suddenly energetic over the last decade, and whether they will remain so in the future. In effect, the report maintains an assumption that these sources will remain extant during the lifetime of the breach, with only longshore power being an independent variable that might lead to different breach outcomes.

iv. ABPmer appears to assume that gravel-based spits have the same capacity as sand-based systems to breach due to backing tidal channel avulsion under extreme supra-tidal water levels. This potential is significantly greater in sand systems than in gravel systems. It is essential to recognise a salient structural difference between gravel-dominated and sand-dominated spits. On gravel spits, the elevation of wave-lain beach crest heights is greater relative to extreme tidal elevation, than for sand spits. This is a strategic difference, in that the potential for surge-generated storm water at supra-tidal elevations in the back spit area, which can enable spit crest overtopping from the rear and thereby cause a new breach across the spit, is significantly greater with sand spits than with gravel spits. This means a low possibility of 'natural' breaching on gravel spits, which is the central issue of ABPmer's "natural' proposal.

v. There is a recurring perspective that natural breaching is a process that occurs at Pagham, despite lack of specific historical evidence that it has occurred before, at times other than when sediment volume in the foreshore has been very low, i.e. sediment scarcity, and not as at present with a positive sediment supply balance. Persistent spit breaching by channel avulsion in sand-dominated systems, where longshore sediment supply is dominant, does occur, but evidence of something similar in gravel-dominated systems is somewhat rare. The other sources of breaching evidence used in the report (Porlock and Medmerry) are partial and idiosyncratic to the specific site and do not lead to clarity in supporting a breaching implementation at Pagham.

vi. There is an assumption that this breach will be self-maintaining and that it will not block, even though ABPmer wish to retain some on-site capacity (needs clarification) for an extra one-off episode of breach clearing: just in case! There is insufficient evidence that the breach will be able to keep its coherency and flow regime at this one site. There seems to be no justification that this breach will differ from the earlier one and resist movement towards the northeast. This does not affect the overall plan, but indicates that

the detail is uncertain. Time lines are, at best, guestimates, which only get more uncertain the further in to the future that is considered (c 10-20 years).

5. Natural England's response to this proposal when deliberating over how this coastal unit (as a SSSI site) is evolving, should consider a long-term perspective over the next 20-50 years, Adaptive management may well be the contemporary watchword, but its partial use in this proposal, is cause for some concern, in that it can negate a holistic sustainable approach for the coast at a larger spatial scale than just Pagham spit. The whole of Pagham Frontage (from Selsey to Bognor) will be stressed by environmental change in the next 85 years (by 2100CE), which will be reflective of past phases of barrier behaviour, albeit by an accelerated rate through rising sea-level change rates. Planning should be regional in scope and reflective of where coastal behaviour is leading through issues of aperiodic sediment supply variations, rather than supporting human intervention on the basis of limited empirical understanding. This report's spatial piecemeal approach is likely to lead to unintended consequences that will deflect the wider natural system.

6. A key axiom of the ABPmer analysis is that the current spit/delta structure is interrupting a longshore sediment supply volume of about 20,000m^3/year. This loss of longshore supply then accounts for the retreat of Pagham Frontage's beach profile over the last decade. Given the 4km Pagham shore length, this denied annual volume would account for about an average sediment loss of c. 5m^3/ m length of frontage, which distributed over the Frontage's profile, tidal range and foreshore width is a negligible volume, and suggests that the Pagham Frontage retreat is more likely related to a longer term depletion of sediment, than just that caused by the presence of the spit/delta system. This situation is a function of the rapid growth of the current Pagham Frontage during the period in which the ebb delta and spit were last extensively reworked in the late 19th / early 20th century. These multi-decade scaled changes in coastal structure are still causing morphological response, and must be seen as the wider background control to the apparent local scale changes of the Church Norton spit and Ti/o positions. Coastal retreat as a consequence of cannibalisation of older drift-aligned beach ridge systems into a single crest swash-aligned structure is evident elsewhere around the UK coast and Pagham *per se* is no exception to this issue, where longshore supply has been episodic, fluctuating and reducing on a multi-decadal scales.

7. The ABPmer proposal depends on spit breaching identified as a 'natural' and 'normal' process for gravel-dominated tidal mouth/flanking spit system. There is minimal empirical evidence available to support this as a natural process for gravel-dominated coastal systems. There is substantial evidence recorded (from East Coast USA **sand**-dominated barrier islands) that tidal inlet bypassing occurs through tidal channel switching, particularly during extreme flow events (often during hurricane passage). This leads to down-drift beach-bar 'welding' and hence longshore sediment reconnecting to down-drift beach frontages.

8. Natural breaching of a gravel spit is also a function of the relative width of the spit lying above MHWS. This in turn is a reflection of the width of the spit and the volume of sediment lying under the beach profile. Overwashing from the seaward side is radically enhanced on a retreating solitary spit

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crest, which overall is conditioned by a reducing beach face sediment budget, i.e. declining or thinning beaches due to failing longshore sediment supply. The sediment supply context to a gravel spit is a dominant factor in the process of natural spit breaching.

9. If this by-passing has happened in the past at Pagham, then it is likely to have happened during times of: i) longshore sediment supply scarcity; ii) associated beach thinning; iii) minimal foreshore width; and iv) lack of ebb-delta presence. Together these components would allow storm surge (product of extreme event) to first reach and then overwash the beach crest, enabling reduction in the crest height sufficient for storm impounded tidal waters in the backing tidal channel to spill out and incise a new outlet. This situation may have been the preamble to channel switching in the early part of the 20th century, though such persistent tidal switching may have been artificially (human) adjusted to maintain any new breach position.

10. The Pagham spit and delta system is at present dependent on a re-energised (over the last decade) northeast-directed longshore sediment transport volume, which has forced the substantial increase in CN spit and associated ebb-delta. Rates of change have been recorded as amongst the highest of such features within GB, though most of changes in other spits tend to be historically averaged and therefore are lower rates than the 'immediate' storm changes available for Pagham during the past three years Ebb delta extension leads the spit extension in spatial development, and where no ebb delta platform exists, then the spit moves tight against the existing foreshore, or waits for the delta to be developed. The lack of delta platform along the present Pagham Frontage has allowed the recent spit extension, during the '2013-14' southwest storminess period, to force the Ti/o tight against Pagham Frontage beach and cause the Frontage erosion both west and east of groyne 4.

11. ABPmer advocates a breaching of the spit to alleviate both the changes of the Pagham frontage around groynes 3-1, and the background cannibalisation of the immediate down-drift frontage beyond groyne 1. This begs the question as to what would happen if no breaching action was undertaken? Any No-Action outcome would be dependent on the longshore supply rate:

    i) If the longshore supply rate persists, then the spit will try to extend against the lateral bend in Ti/o at groyne 3, potentially echoing what happened in the demise of groyne 4 in 2014, by undermining the rock revetment and forcing the Ti/o against the middle/upper beach.

    ii) If the longshore rate was reducing, then the spit system is likely to cannibalise and start to rework the spit longshore. The spit would be unlikely to extend as quickly, but if the sediment supply picks up again, then continuation of the spit would be likely to occur as identified in i) above.

12. Given no breaching action, regardless of source supply variation, the spit is likely to extend longshore, with the Ti/o trying to extend an ebb delta sub-tidal platform in an eastwards direction. On that basis, it is the presence of groynes 3-1 that would be causing the extra difficulty of the near right angle turn in the direction of the Ti/o at the upper beach position. There is logic in

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removing these groynes to allow the unimpeded lateral shift of Ti/o. The continuing presence of these groynes is causing more problems, than solving erosion in the current context. Their future presence would still be an inhibitor to Pagham longshore resupply, even if the breaching was undertaken, as the groyne presence will inhibit the transport corridor connecting any subsequent reworking of the distal spit sediment to the eastward part of the Pagham Frontage.

13. There needs to be a reworking of the whole CN spit (plus ebb delta) to provide sufficient sediment resupply along the Pagham Frontage, in order to counter the last decade's recession (see paragraph 4ii). A 'sufficient' sediment supply to maintain Pagham Frontage is unlikely to come from the proposed breach and its associated reworking of distal CN spit sediment volume by wave activity.

14. I have some concern over the clarity and confidence shown in the proposed breach cross-section. Why should it be self-flushing and self-maintaining? The difference in the peak tidal flows between the present outlet and the proposed outlet are only a few cm/sec under spring conditions, such that for probably 95% of the time there is going to be similarity in both flow and asymmetry in both the existing and proposed Ti/o channels. Given that the longshore sediment supply is currently in excess of the Ti/o capacity to hold its position, then in all probability the new breach is not going to be self-maintaining, especially when above mean annual longshore supply volumes are transported. Excess sediment supply will start to fill and force the breach mouth to move longshore. It is likely that as a self-flushing channel under 20,000m^3/year longshore flow, then a new breach will create a new 'groyne effect' and back–up further longshore sediment to the western side. If the sediment supply is closer to 30,000m^3/year, then the entrance will start to move due to deflection towards the east-northeast. It would be reasonable to infer that given rates between 20,000m^3 and 30,000m^3/year, there will be uncertainty as to the outlet's spatial persistence

15. I am still trying to understand the detail of how the breaching operation will be conducted: Medmerry had no inlet flow to contend with, so citing Medmerry as the basis for doing this breach is not much help. Anyway the planned Medmerry breach is unlike the extant entrance two years post breaching, with the '13-14' storm wave events doing much of the alteration (Bradbury: pers com, November 2014: Masselink et al., 2015). Medmerry is not the best experience for a breaching proposal at Pagham. Likewise Porlock breach (claimed as experience) was natural with a degenerate hurricane doing the excavation work. There is no evidence from this site to indicate how adaptive management action facilitated or controlled the breach change. Furthermore Medmerry evidence shows a major reworking of mouth breach and side slope architecture beyond what was planned: such changes scaled to Pagham indicate that the side bund to be constructed to block the old Ti/o channel may well be compromised. The proposed breach may alleviate the impact of the contemporary Ti/o at Pagham Frontage, but to what extent and for how long is uncertain. The 8-20 years proposed forecasting lifetime of the project needs further clarification: what assumptions are being made concerning the spatial impacts of the breach and the associated down-drift beach adjustments. These are needed to give further clarification to the lifetime to the proposal.

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16. The proposal identifies post-breach reworking of the down-drift side to prograde the Pagham Frontage, i.e. a redistribution of the distal spit sediment. As the distal spit retreats, then there will be an adjustment of the wave refraction pattern that may reduce easterly longshore sediment transport. Even without the change in breach position the likely wave refraction adjustment to a changing shoreline angle from northeast (distal spit) to east (moving along Pagham Frontage) is likely to reduce the potential for Pagham renourishment from the distal source. The presence of groynes 3 to 1 will only serve to further reduce the potential of longshore sediment to move past to the eroding (eastern) Pagham Frontage section.

17. Davies (1972) made an observation that Ti/o tend to spatially gravitate towards positions where breaking wave heights are lowest in the overall longshore gradient. Highest breaking waves are often associated with wave refraction focusing of wave orthogonals. Such focusing is more likely along the apex of a protruding spit and delta system. The apex is where the proposed breach is designed to be located, such that the breach will be likely to move again towards the distal flank (contemporary Ti/o position) under longshore sediment deposition pressure. This tendency should be considered as a further unknown uncertainty in the breaching proposal.

18. The central policy thrust of the proposal is identified as being 'Adaptive Management', an approach adopted in the local coastal defence strategy. Yes it is adaptive in trying to work with perceived coastal behaviour, but its cited justification appears paradoxical, given that the breaching proposal is a piecemeal attempt to further support a 'Hold-the-Line' mode of the bigger coastal unit (Pagham Frontage) in which the spit and delta complex is situated. It would seem on balance that the proposal is only trying to reset the geomorphological clock back by about five years, whereas the future of the spit and Ti/o should be considered in terms of overall coastal behaviour and evolution of the coastal system between Selsey and Bognor on a longer-term basis. By 2100CE there is a 50% certainty that sea level rise will by 0.8m along the south coast (Grinsted *et al.*, 2015). This scale of sea level change will accelerate forcing of Pagham Frontage retreat. The longshore sediment demand to resist such change is unlikely to be supported by the scale of sediment reworking indicative of this proposal. In this context, the proposed deflection of a natural coastal system should be resisted, on the basis that there is likely to be little gain from the proposal, set against the proposal's unnatural and non-normal disruption to an important coastal system.

Natural England Advice Responses

19. *Q: Does the report provide a reasonable analysis of the impact on the spit system with regard to its SSSI and SPA interest, the importance of the site and the interest that would be lost?*

20. A: The report provides a statement of the structure and processes involved with the proposal concerning SSSI (direct gravel changes) and SPA (possible Pagham Harbour water level changes, and Little Tern nesting changes). The ES identifies the potential changing evolution of the site and the losses inherent in such changes. It assesses the changes as being of: *no significance* to water level changes to the SPA; *moderate* changes to the Terns roosting areas (to be mitigated by creation of a Tern Island; no direct assessment of the geomorphic changes with respect to future interest, but considers such changes as showing a faster natural evolution pathway for the spit system.

21. *Q: Is the proposal feasible i.e. would the breach remain open as proposed in the application? Do you agree with their estimates of certainty?*

22. A: The 'open' status of the breach will be a function of the longshore sediment transport experienced northeast across the inlet. It is identified that the average transport rate has been about c 20,000m^3/year over the last decade (time of spit growth), while peaking at c 38,000m^3/year during 2014 (mostly during the winter storms of 2013-14). This latter situation is rated as being associated with c 4 to 5 1:20 storms reoccurring in one winter season, which *per se* is probably a 1:50 year occurrence (Dr A Bradbury, Channel Coast Observatory: pers com. 2014). The safety calculations, based on the approach of Hume & Herdendorf (1993) and Hughes (2002), sets the inlet width at 40m for self-flushing (sustainable maintenance) given the mean annual longshore sediment rate (20,000m^3/year), but recognises that if the load is higher than the mean, then the channel may start to fill and hence force lateral movement of the inlet (east to northeast depending on the persistence of the old distal spit). There has to be a degree of uncertainty over this estimation of longshore drift and calculation of the channel width parameters. I would be concerned about the two examples identified for breaching experience (Porlock and Medmerry), both showed considerable alteration of the upper beach architecture around the flanks of their new breached entrance, such that estimating the actual stability of a new breach is not an exact science, with limited empirical evidence to substantiate stability.

23. *Q: How long would it take for the cut distal end of the spit to be 'lost' and where is it likely to go.*

24. A: This is moot point. The proposal indicates between 8 and 20 years for the reduction of this sediment volume. It is estimated the volume is c. 200,000m^3 and technically a mean longshore potential of 20,000m^3/year would rework this volume through in 10 years. However such annual dispersal is unlikely as the role of reverse drift (southwest to west) due to wave refraction around the ebb delta is going to reduce this net northeast dispersal rate. The question of where the sediment will go is also uncertain. The proposal identifies that northeast-east sediment dispersal is the normal

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process for Pagham, with material passed along Pagham Frontage. The presence of groynes 3-1 are already responsible for the cessation of drift alongshore at this position, with the down drift area (Pagham Frontage) already experiencing erosion and retreat of the beach profile. The groynes will still be an obstruction to drift, until they are lost in a localised progradation, and in effect bypassed by some proportion of the breakdown transport from the distal spit. If these groynes were removed then Pagham Frontage may get quicker benefit from the dispersal of the distal spit.

25. *Q: Do you agree with the conclusions in the report, i.e. that it will come on to the beach in approx. 8-10 years max of 20 years?*

26. A: If the groynes stay then, there is a likelihood of the dispersal taking longer than what is proposed. Likewise as the distal spit starts to retreat the feedback in the landward movement of the nearshore profile may induce wave refraction changes that will alter the dominant northeast drift potential. This in turn may reduce sediment feed towards Pagham Frontage.

27. *Q: What is the risk of closure of this breach and therefore the harbour and how would this scenario evolve i.e. would it reopen and where?*

28. A: The report identifies that probability of closure of a 40m breach is high when the average longshore rate is doubled (ABPmer, 2015: vol2, Table 8, p36). The project is thereby dependent on the longshore load primarily fluctuating around the mean annual load capacity. If any loss of longshore load occurs due to any reducing source sediment, then closure probability is reduced. What is not clear is the degree to which the ebb-dominance of the flow is capable of moving all the longshore sediment flux seaward. The tidal flow is moving the sediment within the tidal frame, but wave action particularly during storms from the southwest to southeast vectors may well sweep flood orientated spits into the channel edges, though without upper beach sedimentation they would remain structurally unsound as side-ridges and move under gravity into the channel. Thus the channel could start a process of western side deposition and eastern side erosion, by which the channel would move east to northeast. Its capacity to stay open is still dependent on tidal prism and the degree to which this may move into a non-ebb dominance during neap tide flows (symmetrical flow regime). This is where the dynamic suggested of keeping the system open by self flushing has to be balanced against the change in flow regime, as the channel is forced laterally and thereby potentially less efficient in ebb-dominance status.
    It is only an "expertise" observation, but there is, on current showing, a lower likelihood for the contemporary Ti/o to be blocked by on-going sediment movement, than the proposed breach. This likelihood increases proportionately as the annual longshore rate moves above a 20,000m^3 threshold for the proposed breach.

29. Q: How long is the extended spit likely to persist for:
    a) If it was left to its own devices (albeit almost impossible to answer as it is heavily dependent on the longshore sediment supply)?
    b) If the current onshore sediment supply was to 'cut-off' within the next 5 years?
    c) Answers to these questions should be seen in the context of 39A below.

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30. A: Timing of spit changes will depend heavily on the supply of sediment to feed the available longshore sediment transport rate. Continuance of sediment supply will force the spit to extend (para. 11i). This rate of extension is going to be slower than the overall last decade rate, given the rotation of the coastal alignment of the spit extension, relative to the dominant SW wave attack. The angle between the breaking wave and the shoreline will reduce as the wave approaches Pagham Frontage, compared to the flank of the existing spit/delta system, and therefore one could expect the spit's beach face to aggrade given the reduction in longshore wave power. This makes any natural breaching of the spit along the Pagham Frontage less likely. Thus while the duration of the spit extension is uncertain, the 'inevitability' of breaching within the next decade is unsupportable.

31. B: Without any fresh sediment from the up-drift sources, then the spit would be cannibalised (para. 11ii). Assume that the spit has received something between 200,000m^3 and 300,000m^3 of new sediment over the last decade. Given a mean wave power forcing c 20,000m^3 a year of longshore transport, then crudely the system would need c 10-15 years of similar wave forcing to remove the sediment into any extension alongshore (albeit with the effect of Groynes 3-1 as already mentioned in para. 26). This is only a 1st order approximation as it does not take into any account that cannibalisation often proceeds in spatial fits and bursts, such that there is no certainty that the erosion process would work through the existing spit in a clean concise manner. The last decade has shown how the spit growth was temporally slowed and accelerated; likewise any spit dispersal would also likely be prone to such variations. This cannibalisation process would lead to a progressive barrier thinning, as part of the swash-alignment of the up-drift end of the spit. There is always the possibility that as the barrier thins progressively west to east, then the barrier may be breached in the up-drift swash-aligned section. I have assumed that the cannibalisation would start near the Church Norton end of the system (Orford et al., 2001) and therefore any new Ti/o breach is more likely at this end (reflecting past conditions in the early 20thC). Again the timing may be speeded up by the incidence of more energetic winters. The increased longshore transport rate of 35,000m^3 during the winter 2013-14 season is more than likely a foretaste of increased rates in the next few years, given the changing winter North Atlantic air mass dynamics of recent years. Assume that the mean longshore power available in future years rises to a conservative c.25,000m^3 and that the system is cannibalising from the up-drift end, then an initial swash-alignment to the west of the delta may occur within a decade of the current supply terminating. The variables in the system (supply rate, wave refraction changes, extreme storm event return periods) make the possibility and timing of a new Ti/o opening uncertain.
    The extension of the spit and capacity of the contemporary Ti/o to be the principal opening has already been discussed above (24A)

32. *Q: What are the uncertainties around this proposal and can they be resolved?*

33. A: Chief uncertainties:

    i) Mean longshore sediment supply maintenance at c 20,000m^3/year.
    ii) Alteration of Ti/o architecture by direct wave action and sediment deposition.

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iii) Dispersal rate of distal spit sediment volume.
iv) Dispersal rate of sediment along Pagham Frontage.

34. *Q: Are there always going to be uncertainties due to the dynamic processes involved?*

35. A: Yes

36. *Q: Is any more information needed in respect of coastal processes that could help Natural England determine its advice on this proposal?*

37. A: A less uncertain assessment of the reduction of the distal spit by wave reworking is required. In this analysis, some indication of shifting wave patterns along the distal spit, and hence any alteration to the net eastwards longshore sediment transport, would be helpful. Likewise explore options for understanding the offshore supply process, which is at the heart of this proposal, yet remains remarkably un-studied. There is also need for more supportive detail on the method of breaching via stages by which excavation is to be undertaken, highlighting points of machinery operations and general machinery movements on both sides of the proposed breach during the overall action.

38. *Q: How do you assess the alternatives, are there any options that are less damaging to the natural environment with either less uncertainty or equal uncertainty?*

39. A: Phased removal of groynes 3-1 over several winters. This would allow a free eastwards movement of the Ti/o, modulated by extension of the spit terminus dependent on maintaining longshore sediment supply. Frontage in the wake of the outlet (west side) would be protected from wave attack by the extending spit. The inlet would still feed some ebb-delta extension in a more rectilinear zone along the eastern frontage and help to dissipate incident wave energy. Regardless of longshore supply fluctuations, as the spit extends there is less sediment to aggrade through the spit, such that localised cannibalisation of the proximal Church Norton spit could ensue driving a swash refraction status with a reducing barrier and foreshore as a consequence (Orford et al., 2001: see Glossary for description of this process). Over time this swash alignment will move eastwards rolling the spit's sediment volume also eastwards, alongshore in front of Pagham. This may then allow a future possibility of an avulsion breach at the Church Norton end of Pagham Harbour. This situation might be similar to conditions prevailing during a previous "natural" breach, observed in historic map evidence, i.e. thinning upper beach barrier and low foreshore sediment volume.

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Glossary

Drift-alignment: Descriptive term indicative of a beach or beach-ridge system dominated by active longshore drift, and typical of prograded beach-ridges. Drift-alignment is generally indicative of greater up-drift sediment input, than down-drift output. In plan-view, drift-alignment is associated with increasing beach width in a down-drift direction.

Swash alignment: Descriptive term for a beach or beach ridge system associated with weak longshore drift. The term applies to a sediment-starved single beach ridge, generally indicative of greater down-drift sediment output, than up-drift input. In plan-view, swash alignment is associated with diminishing beach width moving progressively along the barrier in a down-drift direction. Swash alignment is generally associated with cannibalization of up-drift beaches, and a subsequent breakdown (disarticulation) of longshore barrier/beach continuity into segmented sections characterized by smaller scale up-drift beach bays leading into down-drift mini beach-accumulation headlands. Hence swash-alignment can be observed at different scales from coast cell (km) to local beach (m).

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25 April 2016

Item D

Specific comments from Natural England on the likely impacts and potential mitigation measures

The information below is intended to assist in the assessment of impacts and the identification of possible mitigation measures for the SPA/Ramsar site.

It should be noted that some mitigation measures may address impacts common to several designated features.

1. Further information required for the Appropriate Assessment (AA) with regard to the SPA and Ramsar site

1.1 The joint local authorities'/ MMO letter of 7th March stated that an Appropriate Assessment is required to address the impacts of the proposal on the Pagham Harbour SPA/Ramsar site. Our advice provides information to inform the three main issues. These are:

I. Impacts to the little tern population - through loss of breeding habitat and the potential increase risk of disturbance and predation (**see 1.7 below**).

II. Impacts to SPA/Ramsar bird populations due to changes in supportive habitat within the harbour through the risk of harbour closure (**see 1.8 below**).

III. The impacts of construction on bird SPA/Ramsar bird population – via disturbance and changes to supportive habitat (**see 1.9 below**).

1.2 To help inform the assessment of these impacts, the information below provides details of the SPA conservation objectives, and advice on each of these three issues.

SPA conservation objectives and Ramsar information

1.3 Pagham Harbour SPA – conservation objectives and the citation can be found at this link:

http://publications.naturalengland.org.uk/publication/6147434560356352?category=6528471664689152

1.4 As part of the package of advice (item B), we are providing the preliminary draft of Pagham Harbour SPA conservation advice which has been prepared for used in assessment of plans or projects that may impact on this site.

1.5 Pagham Harbour Ramsar – information sheet for the Ramsar:

http://jncc.defra.gov.uk/pdf/RIS/UK11052.pdf

1.6 In addition, below is a link to the 'The Habitats and Wild Birds Directives in England and its seas: Core - guidance for developers, regulators & land/marine managers':

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82706/habitats-simplify-guide-draft-20121211.pdf

1.7 Impacts to the little tern population - through loss of breeding habitat and the potential increase risk of disturbance and predation

1.7.1 The measure put forward as part of the application, to compensate for the impact on the little tern habitat and breeding population, is a proposed habitat island on the Church Norton side of the harbour. The RSPB has provided advice on the proposed little tern habitat, and we have provided further comments on this to help inform the requirements of the compensation habitat, as item E.

1.7.2 Regarding the increased risk of disturbance and predation, we advise that the necessary mitigation will be likely to include both wardening and predation measures to cover the distal end of the spit. These measures will be necessary once the distal end is joined to the Pagham frontage by the shingle bund, making it more accessible but whilst it still remains suitable habitat for nesting terns.

1.7.3 At the meeting on 11th February the RSPB offered to assist with these mitigation measures. We advise that this should cover:

i. Ensuring there will be effective wardening of the site throughout the nesting period to prevent people and dogs disturbing nesting little terns. This should be in place for as long as it remains a viable nesting habitat for little terns.

ii. Fencing and signage in the nesting season to prevent access by people to the spit via the shingle bund which is to be constructed, and the distal end of the spit as it joins the Pagham frontage.

iii. Fencing for fox control in the nesting season and potentially other predation controls (rats, etc.) as required to prevent predation on little terns on the distal end of the spit.

iv. Monitoring of the effectiveness of these measures.

1.8 Impacts to SPA/Ramsar bird populations due to changes in supportive habitat within the harbour through the risk of harbour closure

i. With regard to harbour closure, plans should offer sufficient certainty that the breach will remain open or that sufficient mitigation measures are in place to re-open the breach.

ii. We recognise that the ES states (p121) that 'it is not proposed or advised that there is a regular campaign of maintained work at this site.' We agree that there shouldn't be a requirement for regular dredging as the proposed breach is being designed to be relatively self-sustaining and because regular maintenance dredging has the potential for further impacts on the site. However, given the risks to the site of the breach closing as a direct result of this intervention, we advise the AA should consider the potential need for the breach to be opened more than once, i.e. beyond the once-only offer in the ES. The contingency measures should be planned over such time as there is a possibility of closure as a result of intervention.

1.9 The impacts of construction on bird SPA/Ramsar bird population (including little tern population) – via disturbance and changes to supportive habitat during construction

1.9.1 Disturbance from construction on breeding and overwintering SPA/Ramsar populations:

i. The disturbance impact from construction can be significantly reduced if construction begins immediately after the little terns have left the site and prior to the arrival of the majority of the over-wintering birds. Ideally this is when the construction should be undertaken – an ecological watching brief can confirm that all little terns chicks have fledged before works proceed to provide certainty that the breeding season is over.

ii. To avoid significant impacts on the SPA/Ramsar birds it needs to be confirmed (as stated in the ES) that construction will occur outside of the little tern breeding season. The use of on-site monitoring, or confirmation by the RSPB should be used to indicate that the breeding season is complete.

1.9.2 Disturbance of the SPA/Ramsar wintering waterbird features during construction of the proposal should be further considered in the AA:

A Construction Schedule and/or Construction Management Plan would be a good way to address these issues with an ecological clerk of works to ensure their implementation. We advise consideration of the following:

i. The 50m zone appears to be based only on the potential impacts of plant/machinery movements[1].

[1] 'IECS (1997), referenced in the ES, noted that a person approaching feeding birds on a mudflat caused birds to fly when the person was approximately 300m from the birds, whereas machinery could approach birds within 50m before the birds moved away. See ICES (1997) Saltend Development Cumulative Impact Study: Ornithological Impacts. Report to Consultants in Environmental Sciences Ltd. Report number ZO80-97-F. ICES: University of Hull, 28 pp.

ii. Evidence cited in the ES suggests there is the potential for disturbance from people at a distance up to 300m. A construction plan will help to deal with this disturbance if it incorporates the following measures:

- Minimising the number of personnel on site and the degree to which people enter and exit vehicles, particularly in sensitive areas. Further measures could include providing information to personnel working on the site regarding the sensitivities, and undertaking a watching brief.

- The impact within the disturbance zone may also be lessened if activities are undertaken earlier in the over-wintering period, when the number of over-wintering birds is lower and there are potentially other areas for the birds to use.

- An ecological watching brief should be incorporated into the plan to monitor activities.

iii. WeBS data (low tide and core counts, as provided in the assessment) can be used to assess impacts on the individual species in these exclusion zones, i.e. the species and the numbers that are likely to use the potential disturbance zone and the significance.

NATURAL ENGLAND

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2.1 With regard to the interest features of the SSSI and MCZ sites, further information is required on the potential impacts, and we have provided advice and a number of mitigation measures in the following sections.

2.2 SSSI interest - Vegetated Shingle

2.2.1 The Environmental Statement (ES) identifies the direct loss of perennial (sea kale) vegetated shingle. This area is characteristic and typical of early pioneer vegetated shingle, with its sparse vegetation reflecting the way in which shingle is colonised. It is proposed to offset this loss through creating a new area of habitat where the excavated material is placed across the existing tidal channel. Detail on the construction method would help to increase confidence in the success of the proposals.

2.2.2 The main mitigation for vegetated shingle comes from the potential for vegetated shingle habitat to become established on Pagham beach, through the sea reworking the shingle. Methods to protect this establishing habitat from trampling/disturbance and invasive species, should be considered e.g. working with the community/signage etc.

2.2.3 A construction plan should be provided to ensure protection of the surface geomorphology shingle ridges and the associated vegetated shingle. This should detail the type and number of vehicles on site and the routes to be taken by these vehicles and personnel to access the site, as well as storage and construction locations. Vehicles should stick to existing paths/tracks and particularly on the spit travelling below the mean high water line where any disturbance to shingle would be re-distributed at next tide, and no vegetated shingle is present. Generally vehicles should try and to keep off the shingle as much as possible, including the newly formed ridges where the annual vegetation will establish, and areas with existing vegetation.

2.2.4 A map of the proposed routes storage sites or other areas should be provided and personnel working on the site should be briefed regarding the sensitivities.

2.3 SSSI breeding birds

2.3.1 Of the SSSI breeding bird assemblage there are two species - oystercatcher and ringed plover - whose entire populations at Pagham Harbour appear to nest almost exclusively within the breach area (information is given at the end of this section on the breeding habitats of these two species). We recognise that the ES identities this issue and considers the WeBs data.

2.3.2 One of the reasons these birds nest on the spit is that it is relatively free of disturbance compared with other areas of the harbour. We suggest that the applicant discusses other potential locations which would also provide nesting opportunities within the site with the RSPB and considers this alongside data on how these sites may already be utilised by existing bird populations and therefore whether there is capacity..

2.3.3 Subsequent monitoring of these populations should be carried out, but we advise consultation with the RSPB as this may already be covered by their monitoring programme.

2.3.4 Below is information on oystercatcher and ringed plover breeding habitats:

- **Oystercatcher**

This species breeds on coastal saltmarshes, sand and shingle beaches, dunes, cliff-tops with short grass and occasionally rocky shores, as well as inland along the shores of lakes, reservoirs and rivers or on agricultural grass and cereal fields, often some distance from water (Hayman *et al.* 1986, del Hoyo *et al.* 1996). Taken from: http://www.birdlife.org/datazone/species/factsheet/22733462

See also:

http://www.birdlife.org/datazone/userfiles/file/Species/erlob/summarypdfs/22733462_haematopus_ostralegus.pdf - this has a table of habitats and notes which are suitable breeding or non-breeding habitat for oystercatcher.

- **Ringed plover**

Ringed plovers are solitary nesters that breed primarily on sand or shingle beaches. They can also, occasionally, be found nesting at gravel pits, on short grassland or open arable land (Birdlife International 2016). Ringed plovers are highly site-faithful (Pienkowski 1984; Jackson 1994).

Based on info in: http://www.birdlife.org/datazone/species/factsheet/22693759

See also:
http://www.birdlife.org/datazone/userfiles/file/Species/erlob/summarypdfs/22693759_charadrius_hiaticula.pdf - this has a table of habitats and notes which are suitable breeding or non-breeding habitat for ringed plover.

2.4 SSSI - Geomorphology Interest

Pagham Harbour SSSI is designated for it geomorphological interest with regard to its double spit system and associated ebb delta.

2.4.1 Potential mitigation measures to address the impact are detailed below and focus on allowing the geomorphology of the site to evolve as naturally as possible (i.e. without further human intervention) in the future following the breach. Whilst not avoiding an impact to the existing interest, the suggested mitigation measures will assist with the recovery of the SSSI interest, and substantially benefit the future interest.

2.4.2 Some residual impact on the geomorphology remains (loss of the rapid expansion) and the decision maker will need to weigh up this loss when considering the protection of the properties.

Possible mitigation measures

i. Allow the position of the 'breach/mouth' to evolve without further intervention. If re-opening of the breach is required, this should seek to avoid fixing the harbour opening and should avoid the loss of shingle from system. It is appreciated that the requirement to intervene to re-open the harbour inlet should be limited as the proposed breach is being designed to be relatively self-sustaining.

ii. The construction plan being provided by the applicant should ensure protection of the surface geomorphology of shingle ridges and recurves. This plan should detail the routes to be taken by machinery and personnel to access the site and the construction locations. The general advice is to stick to existing paths/tracks and particularly on the spit to travel below the mean high water line where any disturbance to shingle would be re-distributed at next tide. In general vehicles and personal should keep off the shingle – particularly the newly formed ridges and recurve features.

iii. The lowering of the inner part of the wide existing crest of the 'historic' spit located updrift of the breach could also be considered (see figure 1). Presently, the crest here is artificially elevated as a result of historic engineering works, and will prevent the natural evolution of the spit via periodic overwashing of gravel. Lowering the crest to a more natural level would avoid this issue.

iv. Opportunities to remove relict hard engineering structures (e.g. remnants of historic training walls in the south west of the Harbour to the rear of the Church Norton end of the spit) could also be taken - see figure 2. These structures are likely to have a detrimental effect on the SSSI geomorphology interest by restricting the natural evolution.

v. Consideration would need to be given to impacts on other interest features that may be impacted by any mitigation works.

vi. We advise that it should be ensured that the regional monitoring programme will capture the post-breach evolution of the spit to allow interpretation of the evolution of its coastal geomorphological interest. This could be achieved through discussion with the local authorities and the Channel Coast Observatory.

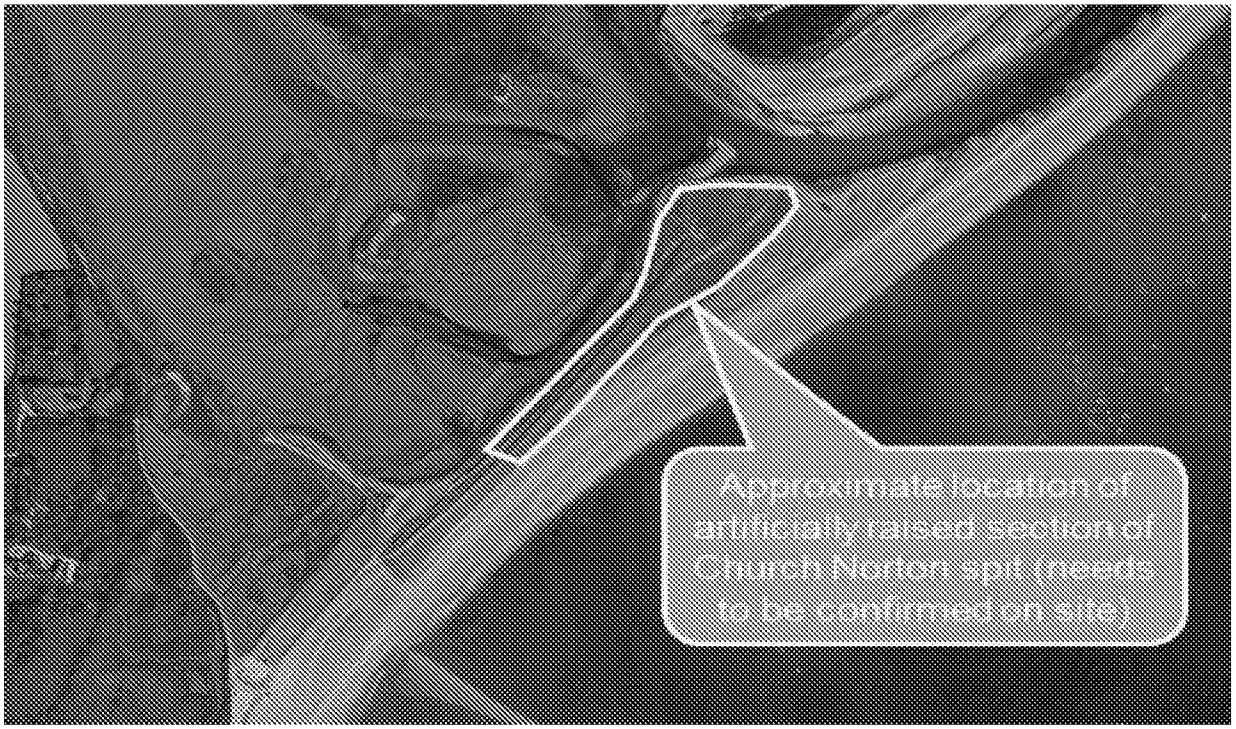


Figure 1: Showing the approximate area of the_artificially elevated spit

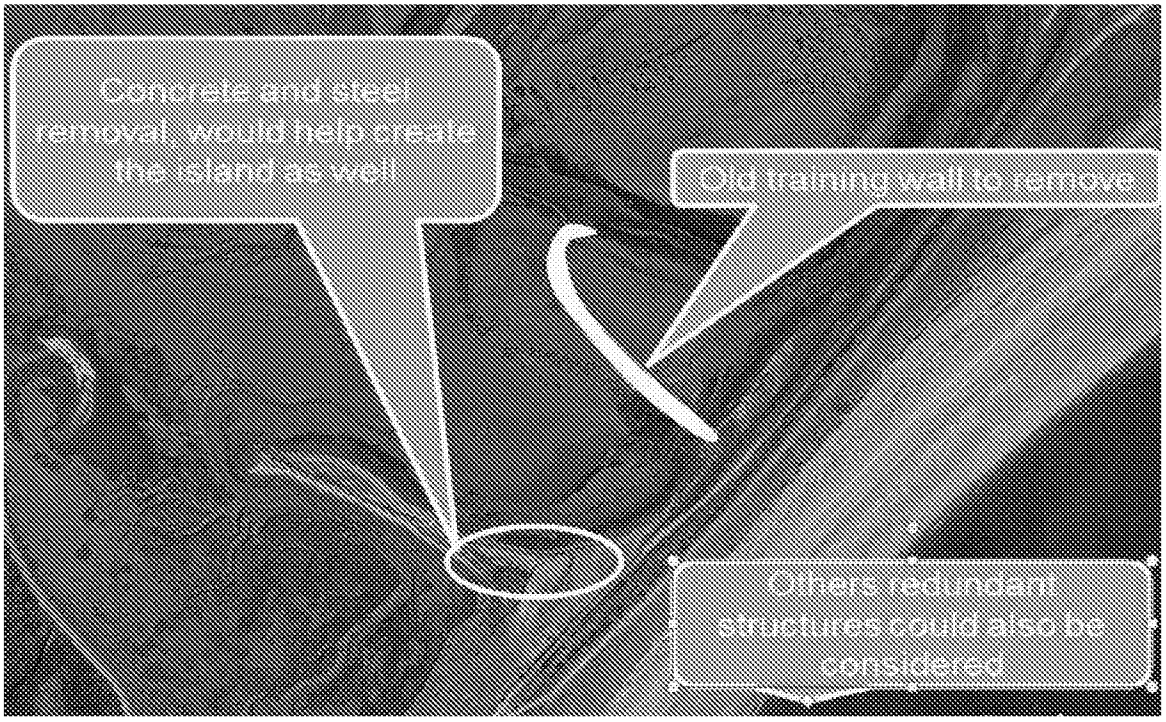


Fig 2.Relict hard engineered structures

2.5 Consideration of the MCZ interest features for the stage 1 assessment

2.5.1 The potential impacts of the proposal on the MCZ designated features - including DeFolin's Lagoon snail, the seagrass beds and the lagoon shrimp, relate to their requirement for a saline influence that is currently maintained by the harbour's regular tidal inundation. The harbour closing for any substantial period may impact these features. Mitigation which ensures the harbour remains open for the SPA/Ramsar bird features is likely to address this concern.

2.5.2 Construction impacts on the DeFolin's lagoon snail around Little Lagoon with regard to siting and access for vehicles. The ES proposes this location for siting machinery and a point of access to the area for the shingle bund construction. The impacts are likely to be through compression and compaction of the shingle. This impact could be avoided by having a construction buffer zone of between 5m -10m around Little Lagoon, (there is fence line already in place) and using existing track ways and paths, and not turning vehicles on shingle but reversing back along exiting tracks. This detail could be set out in a construction plan that details the routes for construction vehicle and personnel and the areas to use and those to avoid.

2.5.3 Natural England has advised that there is no requirement for any further surveys for the DeFolin's lagoon snail within the recently accreted distal end of the spit. This is because, based on the snail's life-cycle which limits its dispersal, the snail is unlikely to be present in this very recently accreted shingle.

2.6 DeFolin lagoon snail on the revetment

2.6.1 There is the potential for the proposed tern island to have an impact on the snail in this location. During one of the surveys, dead specimens of the snail were found on the revetment. Placing large amounts of shingle over this area may smother any snails present in the area. We advise therefore that the island should be designed to ensure that new shingle does not have to be placed over the area where the snail is likely to have its optimal habitat or if further surveys indicated the site is not used by the snail therefore no further alteration to the design would be needed.

25th April 2016

Item E)

Preliminary comments on RSPB's draft information regarding the proposed compensation provision of a little tern island:

1.1 The purpose of this document is to help secure sufficient certainty that little terns will use the proposed island. The RSPB agreed to look at the proposal for the little tern island and their comments are provided in Annex 1. Our initial comments below are based on that information. The RSPB has extensive experience of managing this little tern colony on site and are critical in specifying what is required.

1.2 The proposal is to use the old concrete revetment on the Church Norton side of the harbour to create a new little tern island. See Annex 2 for a map of the location and a photo of the current situation.

1.3 The design note from the RSPB usefully includes much of the information on: island shape, size, profile, height and surface finishing, etc. It also includes information on potential means of attracting little terns to the new island and management measures that may be required. We consider the report is thorough in its approach to creating tern-nesting habitat. It is also really useful to have had the input from Mark Dixon and Malcolm Ausden of the RSPB review the available information and development of the basic design principles for constructed islands undertaken as part of the Medmerry Managed Realignment design process, as well as the experience of Tim Callaway and his knowledge of the site and other adjacent colonies.

1.4 The RSPB could helpfully clarify what evidence has been used to inform the decisions on the various dimensions of the island.

- There is a study that looked at the effect of island size etc. on nest selection of little tern: https://www.jstor.org/stable/23355828?seq=1#page_scan_tab_contents
- There are a number of reviews in Conservation Evidence on the effect of artificial islands, including at least one on substrate and vegetation, and how to encourage nesting through decoys etc.: http://www.conservationevidence.com/actions/480

1.5 The note helps outline prescriptions for creating little tern nesting habitat and might help identify the level of risk associated with creating and managing this type of habitat (akin to off-setting guidance for habitats).

1.6 One of Natural England's colony managers (on the offshore island of Black Law) has reported that little terns were attracted using tape lures and tern decoys and there was success in moving birds, albeit over a short distance <300m. We are in the process of seeking further advice from Natural England's colony managers at sites with nesting little terns and this may add further evidence which can be used.

1.7 Area of new island - size and functional capacity

1.7.1 The RSPB note helpfully calculates that the area of the Church Norton Spit used by the colony in 2015 was c. 175m by 60m (which is approx. 1.05ha), with the majority of the nests in an area c. 155m by 25m (c 0.38ha).

1.7.2 The proposed design suggests that the island should be a minimum of 0.3ha in size.

- There is EC guidance on compensation, including the ratio for area of compensation – see link to guidance on Article 6.4 of the Habitats Directive:

  http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/guidance_art6_4_en.pdf This states (top of page 18) that "*compensation ratios of 1:1 or below should only be considered when it is demonstrated that with such an extent, the measures will be 100% effective in reinstating structure and functionality within a short period of time (e.g. without compromising the preservation of the habitats or the populations of key species likely to be affected by the plan or project)*".

1.7.3 In terms of allowing colony expansion, if we assume an ideal density of 1 little tern nest per $50m^2$ (as suggested in the note) and the new island is 0.3ha, then it could potentially accommodate 60 nests/pairs (=120 little tern adults). So it could achieve approx. 3% of current GB breeding population (1,900 pairs), but that would depend on getting the habitat on the new island correct. We note that there is evidence that relatively small areas of habitat are capable of accommodating much larger numbers of birds than the current Pagham colony size – e.g. as happened at the Hayling Oysterbeds (RSPB pers. comm.), which supported over 100 little terns before predation by rats, etc. overtook events.

1.7.4 We advise however that making the island a little larger during construction will reduce risk and increase certainty.

1.8 Location of the little tern island: some additional questions to consider

1.8.1 Seeking further advice of the RSPB whether there any residual concerns that the proposed location of the island is located in too sheltered an area, close to Church Norton and the tree-line, and whether there are any concerns that its location does not have the same open coast aspect that the spit provides. Is there evidence from elsewhere of little terns nesting in such a sheltered area that could support this?

1.9 Attracting little terns to the new island

1.9.1 Attracting the birds to the site is likely to be one of the biggest risks/uncertainties with the proposal. We agree with the RSPB's approach to reducing this risk through design principles, as set out in their advice below.

1.9.2 Given that the proposal is to use shingle excavated from the breach in the new island, we assume construction of the island will happen at the time of the breach works. In this case, the severed part of the spit will remain for a period of time (exact timescales are unknown), meaning that for at least the first breeding season following the works there will be spit habitat remaining as well as the new island. It would be unlikely, therefore, that there would be a scenario where the birds return and the spit habitat has all gone. Therefore, if no little terns use the island in the first year, further modifications to the island could be undertaken if required. Given that there are likely to be difficulties in attracting birds to the new island from the spit even if the island were in place before the works start, this would represent the most time efficient way of proceeding.

1.9.3 Remedial action/an adaptive management plan could be conditioned as part of the planning process to put things right, if the little terns are not attracted to the island. We would welcome the RSPB's thoughts on how this might be achieved.

DRAFT

Annex 1 – RSPB note on little tern island proposal:

Pagham Harbour little tern nesting island Design
March 2016

Background to island spit design for breeding terns
'Artificial' islands have been used locally by little terns, eg the Oysterbeds in West Hayling LNR, and the M27 'gravel stockpiles'. However, there is a lack of information on the design and subsequent success of constructed islands in coastal waters and Managed Realignment sites.

As part of the Medmerry Managed Realignment design process, a review of the available information was undertaken and some basic design principles for constructed islands were developed in consultation with various RSPB staff (Malcolm Ausden, Chris Cockburn, Jim Glover, Tim Callaway) and Mark Dixon.

As a starting point in design concept, natural islands along the South Coast (primarily Langstone and Pagham Harbours and Keyhaven to Lymington Marshes) supporting breeding terns, were examined.

Simple conclusions were drawn up and used in the Medmerry MR pre-design discussions.
In summary:-

- The islands varied greatly in size, aspect and profile.
- Higher areas of shingle ridges (c0.6 m above HAT) were important for nesting terns
- The smallest tern nesting islands were approximately 0.1 ha and 0.4 ha at HAT in total, but the larger islands could support between 300 – 400 breeding terns and gulls.
- 'New' islands were most attractive to little terns.
- Little terns will nest at high densities (< 1 nest per $10m^2$) but a suggested ideal density might be closer to c. 1 nest per $50m^2$

Introduction to the Pagham Harbour proposal
Pagham Harbour currently supports 20% of the Little tern breeding population for the Solent (Hurst Spit to Pagham Harbour) based on current 5 year means (14 pairs of 69 pairs).

During the 1970s to the mid 1980s the site supported up to 75 pairs, but by 1990 they had ceased to breed in the harbour.

Little terns began to re-colonise from 2007 when 8 pairs raised 5 chicks. Since then the colony has increased to 18 pairs in 2015 raising 16 chicks

The area of the Church Norton Spit used by the colony in 2015 was c. 175m by 60m with the majority of the nests in an area c. 155m by 25m (c 0.38ha).

Tern Island in Pagham Harbour is c 0.4ha but in recent times less than half of the island has been cleared of vegetation to provide ideal little tern nesting habitat and it is more suitable for nesting common tern and black-headed gull.

The proposal to create a new tern nesting island from the 'concrete spit' does not conflict with the EU LIFE Little tern project as the EU LIFE project is focused on restoring 'Tern Island' to optimum tern nesting habitat and anti-predator fencing for both Tern Island and the existing colony on Church Norton Spit

Any new island created will include the main little tern nest site selection criteria:-

- New shingle
- More sheltered from tidal flooding and storms and winds.
- More secure from opportunistic ground predators
- Reduced accidental/intentional human disturbance.

'Concrete spit' as a new little tern island

1. **Location and aspect**

- Close proximity to open sea
- Adequate flows of water around the current concrete spit which reduce the risk of siltation
- Surrounded by water (Broad Rife) even at MLW neap tides
- Reduced exposure to the extent and fetch of most exposed water to minimise erosion.

- Potential for the public to see the breeding and roosting birds reasonably well without causing disturbance.

2. Size and shape

- Minimum of 0.3ha in size (15m - 25m x 160m)
- Minimum of width of 10 - 20m at HAT with a flat top ridge.
- Natural shape (kidney/semi-circular shaped)
    - Shallow profile (1 in 5 to 1 in 8 slope) especially on exposed side
    - 'Flat topped' with simple shingle ridge to leeward side
    - steeper profile on sheltered side and new channel (1in 1 slope)

3. Height

Mean height of the' flat top' of the islands c. 1m above MSHW (0.5m – 1.0m above HAT)

4. Open water around the island

The concrete spit will be turned into an island during the shingle capping process by cutting a new channel (c 10m wide at the base and 1:1 slope) to separate the concrete spit from the main shingle bank.

5. Surface finishing (topography and shingle capping)

Shingle capping - cover and infill around the concrete sheets and re-profile the edges of the new island to reduce erosion and discourage rapid plant colonisation.

The preferred nesting surface for little terns should include a mixture of shingle, graded through 4 mm to 100 mm, but with a high proportion of finer materials on the designed nesting areas (sections above HAT). Average depth of the shingle covering is estimated at 0.3m.

The amount of shingle needed (depending on the extent of infill around the concrete sheets), is estimated at between 2,500 and 3,000 cubic metres.

Cutting the spit off from the main shingle bank by creating a new channel 10m wide at the bed level, could win at least 50% of this required shingle.

6. Use of tape lures and little tern decoys

Little tern tape lures and decoys will be deployed in the spring on the new island to help attract little terns to the nesting areas.

On going management

1. Vegetation

Annual management of vegetation will be required to maintain ideal nesting habitat for tern, as it is on the existing 'Tern Island' in Pagham Harbour and at the Oysterbeds and main islands in Langstone Harbour. Some 'broad-leaved' annual shingle vegetation (e.g. Sea Blite) can be beneficial as it is often used for shelter by little tern chicks.

Grassy vegetation (e.g. Sea Couch) and perennial shingle vegetation (Sea Beet, Sea Purslane, etc.) will be controlled annually to reduce the attraction of the new island to nesting gulls and to prevent grassy vegetation which holds moisture after rainfall and can make sheltering downy chicks more susceptible to hypothermia.

Nesting gulls

On going vegetation management of Tern Island and the new Concrete Spit island should discourage nesting gulls.

We are actively encourage gulls to nest, away from the main little tern sites by the ongoing management of the new islands in Medmerry.

Nesting black-headed gulls and Mediterranean gulls do not necessarily need shingle islands and the artificial islands at Medmerry are designed to attract both species.

Both species of gulls do nest on vegetated shingle selecting locations with the densest vegetation, but they prefer to nest at higher elevations in the upper saltmarsh or even coastal grassland.

2. Predator management

We actively manage predators on all main little tern nesting sites.

Known predator risks at Pagham Harbour currently being monitored by observation and use of nest and 'fence' cameras

Fox –

- Anti-predator fence was up graded to meet suggested specification in 2015
- Nest and 'fence' cameras widely deployed to identify and monitor fox activity (cameras in 2015 showed foxes test the fence after storms and exploit any weak points)
- 'Concrete' spit island will have seasonal anti-predator fencing installed.

Rat –

Rats are present in the area, but have not been recorded recently out on the bare shingle of the spit or on Tern Island, but have been recorded along the strand line

- Use of monitoring points (mammal tunnels and chew sticks)
- Active control of identified with recognised pest control agency (currently working with ADC)

Kestrel –

Kestrels breed locally and routinely hunt nearby grassy banks, upper saltmarsh and areas of vegetated shingle.

In 2015 a male Kestrel provisioning a female and chicks near Pagham was seen occasionally hunting the area around Pagham spit and was observed predating an adult little tern. This seemed to be entirely opportunistic and neither the male or female were observed regularly in the area of the colony, despite hunting the grassy sea wall nearby.

- Kestrel activity is routinely monitored by observation around the colony and nearby possible nest sites located in the spring
- Diversionary feeding will be attempted if the colony is located by kestrels feeding nearby young.

Tim Callaway
17/03/2016

DRAFT

- Annex 2: Map and photos of the location proposed to create a new little tern island on the Church Norton side of the harbour where 1910 breach took place and there are old concrete revetments from the previously installed training wall overlying a bed of shingle.



